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Canada, Conservation Commission of
Committee on Minerals

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CANADA

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MINE-RESCUE WORK IN CANADA

By

W. J. DICK, M. Sc.,
Mining Engineer, Commission of Conservation

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Commission of Conservation
CANADA

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W. J. DICK, M. Sc.,
Mining Engineer, Commission of Conservation

Ottawa : Commission of Conservation : 1912

To Field Marshal His Royal Highness Prince Arthur William Patrick Albert, Duke of Connaught and of Strathearn, K.G., K.T., K.P., &c., &c., Governor General of Canada.

May it Please Your Royal Highness:

The undersigned has the honour to lay before Your Royal Highness a report on Mine-Rescue Work in Canada which has been compiled by W. J. Dick, M.Sc., Mining Engineer of the Commission of Conservation.

Respectfully submitted

CLIFFORD SIFTON

Chairman

Ottawa, Nov. 15, 1912

OTTAWA, NOV. 14, 1912

Sir:

I have the honour to transmit herewith a report on Mine-Rescue Work in Canada by W. J. Dick, Mining Engineer of the Commission of Conservation. The report describes the various types of apparatus used in this work and also outlines the progress that has been made in establishing mine rescue stations in Europe and in the United States.

Your obedient servant

JAMES WHITE

Secretary

HON. CLIFFORD SIFTON,
Chairman,
Commission of Conservation

Foreword

The object of this pamphlet is to encourage mine-rescue work in Canada by setting forth what is being done in this country and elsewhere, by the establishment of mine-rescue equipment stations, to lessen the number of fatalities due to mine fires and explosions.

Mine-rescue apparatus imported by mining companies is not admitted into Canada free of duty. In answer to an inquiry on this point made by the Commission of Conservation, the Commissioner of Customs, under date of Sept. 6, 1912, states, in part, as follows:

> "I am to state that life saving apparatus is admitted free when specially imported by societies to encourage the saving of human life, *vide* tariff item 689. But importations of mine-rescue apparatus by mining companies are dutiable as a rule, according to material. On this basis of rating the probable duty applicable would be 20 per cent. under the British Preferential Tariff and 30 per cent. under the General Tariff items 352 and 454. After duty has been paid on such apparatus imported by mining companies, it is the rule to apply to Council for authority to grant refund, provided the Department is furnished with particulars of the importations, including port number of entry and place and date of entry."

In reply to a further inquiry as to the number and amount of refunds of duty on such apparatus imported during the three fiscal years ending March 31, 1912, the Assistant Commissioner of Customs stated that no refunds had been made in 1910, that, in 1911, two refunds had been made totalling $267, while, in 1912, twenty-six refunds, aggregating $4,313.14, had been made.

Since mine-rescue apparatus is not made in Canada and therefore has to be imported, it is important that mine managers should know that the duty exacted on such importations will be refunded, provided an application in proper form be made.

The writer wishes to thank the Provincial Departments of Mines and the mine operators of the different provinces for the descriptions and photographs of mine-rescue equipment at the coal mines, which are reproduced herein.

W. J. DICK

Ottawa, November, 1912

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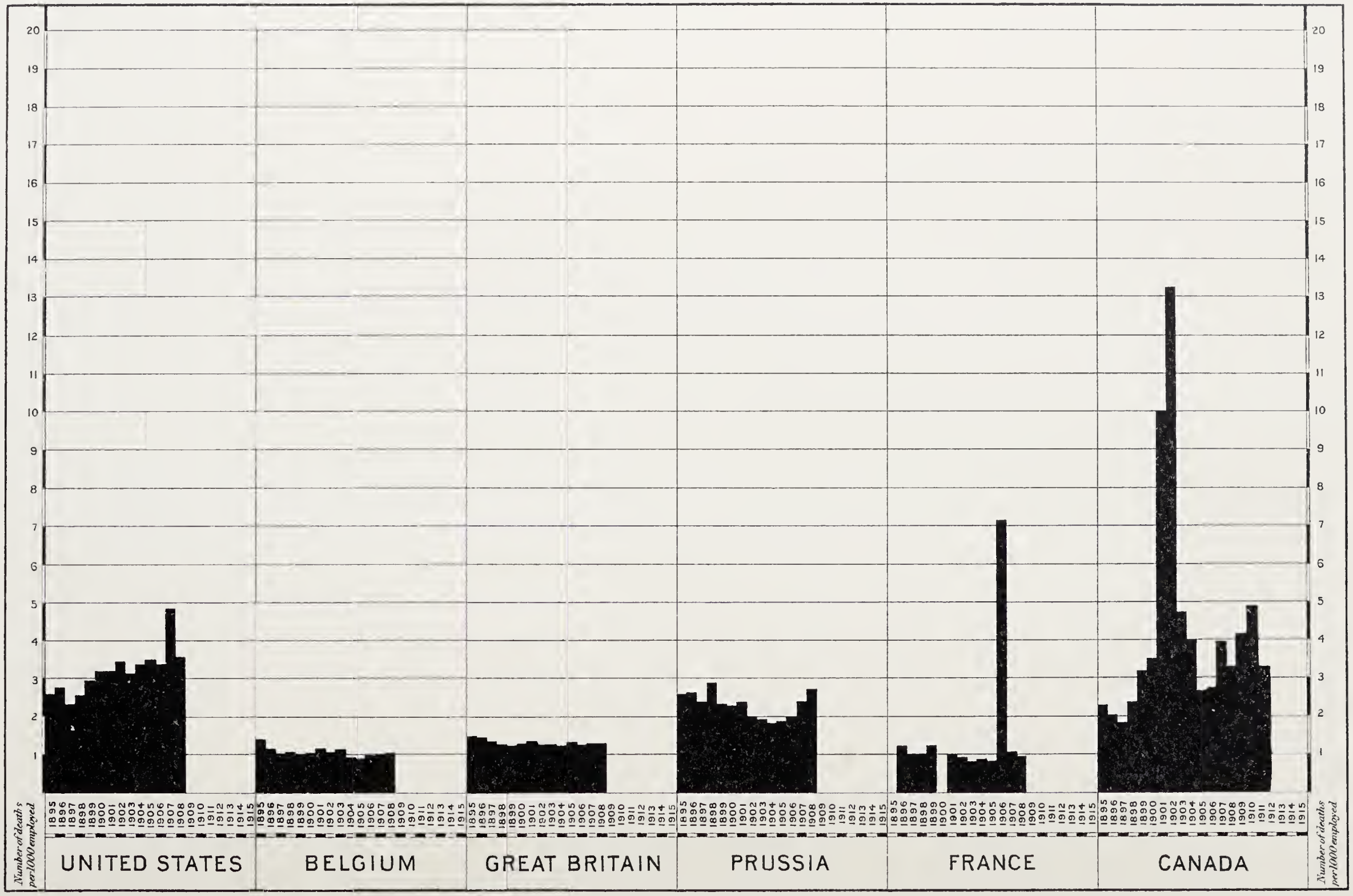
COAL-MINE ACCIDENTS

Number of men killed for each thousand employed

COMMISSION OF CONSERVATION

MINERALS. PLATE Nº XX



Mine-Rescue Work in Canada

INTRODUCTION

THE diagram facing this page shows that the fatality rate in the coal mines of Canada and the United States is considerably higher than that of any of the European coal-mining countries.

Hall and Snelling, in an article on the "Waste of Life in American Coal Mining" * state that the increase of loss of life in the coal mines of the United States has been due, in part, to the lack of proper and enforceable mine regulations; in part, to the lack of reliable information concerning the explosives used in mining, and the conditions under which they can be safely used in the presence of the gas and dust encountered in mines; and, in part, to the fact that, in the development of coal mining, not only is the number of miners increasing, but many areas from which coal is being taken are either becoming deeper or are situated farther from the entrance, where good ventilation is more difficult and dangerous accumulations of explosive gas are more frequent.

In Canada, the high death rate is largely due to similar causes and to the fact that the men generally employed in the mines are not, as a class, as careful as the miners in other countries where coal-mining has become a more specialized science.

The low death rate in all the European coal-producing countries has been due to the effect of mining legislation for the safeguarding and protection of the lives of the workmen, and has been made possible by Government action in establishing testing stations for the study of problems relating to safety in mining, including the use of explosives. With a view to reducing the loss of life incident to mine fires and explosions, Government Mine-rescue stations have also been established. These stations were not established for the purpose of training men for general rescue work, but that the government might have at its disposal, a number of trained men to supervise such operations and to demonstrate to the operators and miners the usefulness of such apparatus. Great Britain, France, Austria, Holland and Belgium, Russia, Germany and British Columbia have made it compulsory for all mines to have a certain equipment of mine-rescue apparatus constantly on hand.

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*Engineering Magazine, Feb., 1908

HISTORY OF MINE-RESCUE APPARATUS

The following is a short history of the growth of mine-rescue work, together with a summary of the laws which have compelled its adoption in the different coal-mining areas of Europe and America.

"The first practical attempts to construct respiratory apparatus were made in 1824 by French engineers.

"At that period the Administration of Mines in France addressed to all its prefects a memorandum in the course of which are found prescribed:

"1. An apparatus with a nose clip, a mouth-piece, and a respiratory tube for free air, developed experimentally by Pilâtre de Rozier in 1785 and completed later by M. Delaunaye's introduction of an anti-mephitic respirator with two valves, and of a lamp supplied with air through a branch of the respiratory tube.

"2. An apparatus with respiratory tubes attached to air reservoirs carried on a rescue car. The memorandum indicated the possibility of replacing the air in these reservoirs by oxygen, as well as that of increasing the amount of air or oxygen carried by compression within reservoirs of sufficient strength.

"3. An apparatus with respiratory tubes to be supplied by blowers, and tubing or piping for the conveyance of the air.

"The circular which accompanied this memorandum from the Ministry requested the mining companies to procure a number of these appliances, but the appeal was not regarded, and it is necessary to pass over a period of forty years before any new progress is to be observed.

"In 1864, we may note the appearance of the Galibert respirator, composed of a reservoir of pure air which the miner carries upon his back, a respiratory tube leading from the bottom of this reservoir to his mouth, and a tube for exhalation leading from his mouth to the top of the reservoir. By this arrangement, the user had between his lips an ivory mouth-piece with two orifices, and, by closing these alternately with the tongue, he might inhale air from the bottom of the reservoir and exhale it again to the upper part. It was possible for a man to breathe thus for fifteen to twenty minutes, but the air became greatly vitiated. To overcome the increasing discomfort which the rescuer must thus suffer, Galibert conceived the idea of modifying the original form of his apparatus. He secured a partial regeneration of the air exhaled from the lungs by causing it to pass over a substance which would remove the

carbonic acid. A little later (1870-1) Rouquairol-Denayrouze conceived his aerophore, which consists of a large sheet-steel tank containing air compressed to 20 atmospheres and carried either on the back or on a rescue car. A tube connects this reservoir with a mouth-piece provided with a pressure regulator, the nostrils of the user being closed by a pince-nez. Shortly afterwards Fayol described various types of respiratory apparatus in which he abandoned the use of compressed air in order to secure appliances little subject to derangement.

"About 1884, Dr. Regnard applied, in an individual portable apparatus, the principle of revivification of the air by means of a reservoir of oxygen and of the passage of the exhaled air into another receptable filled with pumice-stone saturated with a solution of caustic potash.

"Unhappily, as M. Haton de la Goupillière states, all these appliances had a common failing, due to the infrequency of their use: 'At the critical moment the parts of the apparatus would not work, and the men lacked familiarity with their use.' Furthermore, the respiratory apparatus thoroughly tested from 1873 to 1880 at the mines of Commentry, under the direct inspiration of M. Fayol, little by little passed into disuse. The problem was taken up again in Germany and Austria only during the last years of the nineteenth century. But French inventors and constructors, working quietly, have been producing respirators which, little by little, have won their way by their own merit and without useless proclamations. In particular, Lieutenant Vanginot of the Paris Fire Department, has invented an apparatus of which the earlier forms appeared in 1903 and the most recent in 1907. During these four years this respirator has proved itself in many places, even as far as in Russia and Mexico."*

PRESENT TYPES OF MINE-RESCUE APPARATUS

Although there are many types of apparatus now in use, they can be divided into two distinct groups:

I. Portable apparatus with self-contained gas supply.

II. Apparatus and piping which depend on pumps or bellows for their air supply.

Atmospheric air contains 79.04 volumes of nitrogen, 20.93 of oxygen, and 0.03 of carbonic acid, while expired air contains 79.6

* *Rescue Appliances in the Mines of France*, by Jacques Boyer, in Engineering Magazine, April, 1908.

volumes of nitrogen, 16.04 of oxygen, and 4 of carbonic acid. From this, it can be seen that about the same quantity of carbonic acid is given off as there is oxygen absorbed. In other words, in respiration, only 4 per cent. of the oxygen inhaled is taken up by the blood passing through the lungs, the remainder being exhaled without being utilized. To replace this loss of oxygen, there is added to the exhaled air 4 per cent. of carbon dioxide. With physical exertion, the amount of carbon dioxide is increased. It is this gas which, when it accummulates in too large a quantity, becomes a source of trouble, and has therefore to be removed. When more than 1 per cent. is present it causes headache and a sense of distress. Therefore, in all forms of rescue apparatus depending upon oxygen for their gas supply, provision is made for the absorption of the carbon dioxide by passing it through caustic potash or caustic soda. The air thus purified, passes on through the apparatus, and, at a particular point in its circuit, meets and mixes with the oxygen coming from one of the supply cylinders.

Group I—Portable Apparatus with Self-Contained Gas Supply

This group may, for convenience, be classified into those depending on:

1. Compressed oxygen supply—
   (a) Constant supply—Draeger, Fleuss, Meco, Westfalia, etc.
   (b) Automatic supply—Weg.
2. Liquid air supply—Aerolith.
3. Compressed air supply—Vanginot.
4. Oxygen supply generated from sodium-potassium peroxide—Hall-Rees and Pneumatogen.

1. *Compressed Oxygen Supply*

(a) Constant Supply Type.—In the constant supply type, the oxygen is stored in cylinders capable of containing 260-290 litres at 120 atmospheres. It is supplied for breathing purposes, by means of a reducing valve, set to give a constant supply. In some of the apparatus of this type, the reduction of pressure is utilized by means of an injector for circulating the gas continuously through the breathing bag and regenerators, while, in others, the oxygen, after being reduced in pressure, simply passes direct to the breathing and regenerating bag.

(b) Automatic Supply Type.—In the automatic supply type the oxygen is carried in cylinders in the usual way and, by a combination of reducing valves, is liberated automatically in accordance with the amount of exertion.

2. *Liquid Air Supply*

Apparatus of this type depends on liquid air for its supply of oxygen. Atmospheric air liquefies at a temperature of —191°C. and is reduced to about $\frac{1}{700}$ to $\frac{1}{800}$ of its original volume. Consequently, one gallon of liquid air will evaporate into 700 to 800 gallons (110 to 130 cubic feet) of atmospheric air. Liquid air contains two parts of oxygen to one part of nitrogen.

The essentials of this type of apparatus are—

(1) A suitable vessel for containing the liquid air.

(2) An air supply pipe long enough to allow the air to become warmed to a certain extent, thus avoiding discomfort to the user.

(3) An exhalation pipe which is placed in such a position as to facilitate the evaporation of the liquid air by the warmth of the respired gases.

(4) A retarding flask connected to the end of the exhalation pipe, from which the vitiated atmosphere can be discharged at any desired rate.

3. *Compressed Air Supply*

Apparatus of this type depends on compressed air for its supply of gas and has the following essential features:

(1) A compressed air supply.

(2) An indicating reducing gauge.

(3) Respiratory apparatus.

The compressed air supply, which is contained in steel cylinders, is charged at a pressure of from 2,000 to 3,000 pounds per square inch. The reducing gauge is used to lower the pressure of the air contained in the cylinders, to an ordinary tension, and supplies the user with a volume of expanded air. The volume of expanded air may be regulated to the needs of the user by a valve. One of the peculiar features of an apparatus of this type, the Vanginot, is the warning given by a shrill whistle when the compressed air is almost exhausted.

4. *Oxygen Supply Generated from Sodium-Potassium Peroxide*

This type of apparatus is based on the following reactions which take place when aqueous vapour and carbonic acid (both products of respiration) are passed over sodium-potassium peroxide:

$$NaKO_3 + H_2O = NaOH + KOH + 2O.$$
$$NaKO_3 + CO_2 = NaKCO_3 + 2O.$$
$$CO_2 + NaOH + KOH = NaKCO_3 + H_2O.$$

The products of respiration, CO_2 and H_2O, are absorbed, and the oxygen is restored to the wearer of the apparatus.

Nearly all the respiratory apparatus of this group may be converted into, and used as, helmet, half-mask or mouth-breathing types.

Group II—Apparatus and Piping which Depend on Pumps or Bellows for Their Air Supply

This type of apparatus consists of a helmet or similar respiratory appliance supplied by means of pumps or bellows, with a stream of fresh air. The pumps or bellows are connected to the respiratory apparatus by means of a series of flexible pipes. The use of such apparatus is restricted by the limited distance to which flexible pipe can be carried to the wearer. It is useful in dealing with gob fires.

Helmets Versus Mouth-Breathing Devices

Much difference of opinion has existed with regard to the relative merits of masks, helmets, and mouth-breathing devices. Mr. James Paul says—"I think the helmet is not necessary for safe and effective service in unbreathable gases, and that it is a survival of the dress used in submarine diving. To become skilful in the safe use of a helmet the wearer should have much training in unbreathable gases.

"Training in fresh air does not give confidence in the use of the helmet in poisonous gases, and such fresh-air training is a mere waste of the supplies needed for the upkeep of the apparatus.

"In an atmosphere that contains smoke or fumes that irritate the eyes, nostrils, or throat, the helmet may be worn with safety by one who has been thoroughly instructed and trained in its use, for the season that any leakage may be readily detected, but in an unbreathable or poisonous atmosphere that contains no irritating fumes or gases a leak is not detected and the wearer may be overcome. The above disadvantage does not apply to the mouth-breathing form of apparatus, which the writer believes should be used for mine work in an atmosphere that will not support life and which does not contain irritating gases. In addition, the wearer of the mouth-breathing type can examine the roof more easily than can the wearer of a helmet. Some men who have used both helmets and mouth-breathing devices prefer the former, because they can breathe through the nose more easily than through the mouth. An objection to mouth-breathing devices is that they make it more difficult for men to talk to each other when working in a poisonous

atmosphere, but audible signals may be used with success by men properly trained."*

This also seems to be the opinion of the Committee of the South Midland Coal Owners appointed to investigate certain self-contained breathing apparatus with the object of recommending a suitable apparatus in the mines of the South Midland coalfields. The report of this Committee says: †

"A beginner is usually much impressed with the helmet, and at the commencement of his training he is inclined to favour this form of attachment, particularly if the helmet accurately fits him. At the commencement of the tests we were all disposed to imagine that the helmet was the most comfortable attachment. On gaining more experience, however, we ultimately came to the unanimous opinion that the helmet is entirely unsuited for use in mines.

"Helmets, as at present constructed, do not permit of a sufficient field of vision. This renders travelling very difficult, particularly when crawling or looking in an upward direction. For instance, it is impossible to look at the roof of the roadway when in a bending position, and only a very small area is visible without an extensive movement of the face. Unless the helmet accurately fits the particular wearer, the making of an air-tight joint by inflation of the pneumatic rubber bag causes him intense pain owing to the excessive pressure on certain parts, so much so that it may cause severe headache after having been worn for some time. This headache is due to the pressure upon the blood-vessels and nerves of the skin and underlying tissues. Again, helmets made of metal become particularly uncomfortable when used in warm atmospheres, owing to the heat they absorb. The only feature in favour of the helmet is that it permits of the most natural breathing, although the large dead space is by no means satisfactory in view of the fact that some of the expired air is reinhaled with each inspiration."

LAWS REQUIRING MINE-RESCUE APPARATUS AT MINES

The awful loss of life at Courrières, in France on March 10, 1906, where more than 1,100 men and boys were killed, and the fact that thirteen men were rescued after being entombed in the mine for 20 days and one after a lapse of 25 days, demonstrated the necessity of having trained rescue men and apparatus continuously on hand at the

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* The Use and Care of Mine-Rescue Apparatus, Miners Circular 4, United States Bureau of Mines.

† On pages 19 and 20.

mine ready in just such an emergency, so that the miners who escape death or serious injury from the explosion and who may be protected from the carbon monoxide, may be saved. In the case of the Courrières disaster the largest number of deaths was due, not to the force of the explosion, but to carbon monoxide poisoning.

Russia

In Russia, about a year after the Courrières disaster, the following decrees relating to the organization of rescue corps and the installation of rescue apparatus in coal mines, were issued:

"1. In every coal mine a rescue squad must be organized and to it is entrusted operations in foul gases.

"(a) In every mine which has connection with a central organization for the inspection and supervision of rescue corps, the number of workers belonging to the corps must be 4 per cent. of the enrollment of the largest shift. For every four mines belonging to the corps, there must be not less than one breathing apparatus and one electric handlamp. In isolated mines, however, it is required that there shall be not fewer than three complete rescue equipments.

"(b) In mines which are not affiliated with such a central organization, the number of mines required to belong to a corps shall, in general, be the same as in mines of the first category. However, there shall not be less than six men to a corps, and for every three members at least two breathing apparatus and two handlamps shall be provided. In mines having a total force of only 50 men, a corps may consist of three men, having two breathing apparatus and two handlamps, provided the approval of the district inspector has been secured. Mines of this last class must, however, be within 1.5 versts (one mile) of mines having a normal sized corps and have telephone connection with them.

"2. Every gold mine with underground workings and any other mines except those not requiring timbering, must also organize a rescue corps. The size of the corps in these cases, the number of apparatus, electric lamps and other necessary equipment is to be determined by the local inspector after consultation with the mine authorities.

"3. The choice of the particular type of breathing apparatus rests with the mine owners, subject to approval by local authorities."

France

As the result of an investigation by French authorities shortly after the Courrières disaster, the Ministerial Order of 1907 was issued. The following is a short résumé of this Decree, which came into force on April 18, 1908:

Art. 1.—All mines employing more than 100 men underground shall be provided with breathing apparatus capable of allowing the wearer to remain at least one hour in irrespirable atmosphere. Mines employing less than this number of men are exempted, unless very dangerous conditions prevail.

Art. 2.—In gaseous mines, if in connection with a central rescue station, the number of apparatus at each mine may be reduced to two; otherwise, the number must be at least two for the first 200 men on the largest shift, plus one for every 200 men above this number; but no mine is required to keep more than six appliances.

Art. 3.—Non-gaseous mines are not required to keep more than two sets of apparatus.

Art. 4.—The Minister is empowered to group together several adjoining mines for the purposes mentioned in Arts. 2 and 3.

Art. 5.—The number of appliances at a central station is to be determined according to a system outlined in Art. 2, having regard to the largest mine of the group. There shall be not less than one apparatus per 1,000 underground workmen in all the affiliated mines, but no station need contain more than twenty sets of apparatus.

Art. 6.—A central station shall be under the control of a competent engineer or inspector and shall be able to furnish at least ten trained rescuers, or as many rescuers as apparatus is provided for at the station; provided that the number of sets of apparatus exceeds ten.

Art. 7.—The Minister may order any defects of organization in a central station to be remedied.

Art. 8.—The appliances at each mine are to be kept in a depôt, underground or at the surface, within easy reach, and are to be under the charge of an authorized person.

Art. 9.—The apparatus is to be practised with at regular intervals by chosen officials or workmen who are thoroughly familiar with the mine. There must never be less than eight of these men for each pit, nor a less number of men than double the number of appliances; they

must live near the pit, and be distributed as equally as possible among the different shifts.

At least one-quarter of all the underground officials must be able to use breathing apparatus.

Art. 10.—The Government inspectors are to see that these regulations are carried out. They are empowered to make any supplementary regulations they may deem necessary.

Belgium

In 1908, the Crown, on the recommendation of the Minister of Industry and Labour, issued a Decree prescribing the use of special apparatus for affording help to victims of mining accidents or to persons exposed to danger in mines.

The Decree, in essence, was as follows:

Art. 1.—Coal mines having one or more workings which come under the second or third class of fiery mines shall be provided with stations at which portable breathing appliances shall be kept available for immediate use in case of accident in the said workings.

Art. 2.—The number of appliances shall be one for every 200 workmen employed underground in pits of the second and third class. But the total number must not be less than five and need not exceed ten for each mine.

Art. 3.—The appliances shall be selected from among the most perfect types, and they must enable the wearer to remain at least an hour and a half in an irrespirable atmosphere.

They shall always be kept in thorough working order.

Such provision shall be made at every station as will permit all the apparatus being used simultaneously for at least forty-eight hours.

Art. 4.—The management of the mine shall, with the approval of the chief inspector of the mining district, determine the rules for the establishment and working of stations.

Art. 5.—The use of the apparatus shall be entrusted to experienced workmen, who must be thoroughly conversant with the underground workings, and there shall be at least four operators for each apparatus.

These workmen shall, as far as possible, be distributed among the various shifts and shall be selected from among those who live near the stations. Their names and addresses shall be posted at each of the

pits at which their services may be required. They shall be periodically exercised in the handling of the apparatus.

Art. 6.—The Minister shall have power to approve the establishment of a joint station for mines which are close together.

At these stations there shall be one appliance for every 200 workmen employed underground in the pits of the second and third class of the associated mines; but there must not be less than ten appliances and need not be more than twenty. The number of workmen for each appliance mentioned in Art. 5, shall be maintained in each such mine as if it had a separate station.

Art. 7.—The Minister shall have power to grant exemptions, either absolute or conditional, from the foregoing provisions.

Art. 8.—Any contravention of this Decree shall be prosecuted and punished in accordance with Title X of the law of the 21st April, 1910.

Art. 9.—This Decree shall come into force a year after its publication in the *Moniteur*.

Art. 10.—The Minister of Industry and Labour is charged with the enforcement of the Decree.

Austria

Austria recognizes three classes of mines:

(1) Gaseous or fiery mines.

(2) Medium gaseous mines.

(3) Non-gaseous mines.

All mines of the gaseous or fiery group must make provision for mine-rescue work. No provision is made for mine-rescue equipment in medium gaseous and non-gaseous mines.

The following is a brief résumé of these regulations:

Rescue stations, equipped with apparatus of, at least, the 'half hour' type, shall be established at every mine near the entrance to the same. If the rescue station is intended for one mine only, two per cent. of the maximum number of men on the largest shift shall be trained rescue men, such number to be, in no case, less than ten.

Two or more neighbouring mines can, with the authorization of the Department, erect a joint rescue station. In such case, the number of breathing appliances shall be calculated upon the maximum number of men per shift in that mine which employs the largest number of men.

Provision is made for emergencies by placing at every landing in shafts, at least two rescue apparatus, together with electric lamps.

In the rescue station there shall be a number of electric pit-lamps and smoke goggles equal in number to the rescue apparatus, also a suitable quantity of material for the rapid formation of temporary air stoppings.

The rescue appliances shall be kept in good order and be under the charge of a person appointed for that purpose, who shall keep an inventory of all the appliances and report on the testing of the same from time to time.

There shall be, at each pit, a number of workmen, exceeding by, at least two, the number of breathing appliances required, who shall be trained as a rescue party. Care shall be taken that such men are suitably distributed throughout the various shifts. It is advised that the rescue parties of neighbouring mines be united to form a rescue corps. The men of the rescue party thus united into a corps, must make themselves familiar with the main travelling roads of the neighbouring mines in which their services may be required for rescue purposes.

The manager shall, so far as practicable, make certain members of the party acquainted in advance with the part that they will take in carrying out special measures in case of a catastrophe.

The manager shall issue an order to the effect that, in case of accident involving danger, a 'state of permanent service' shall be declared so that all members of a rescue party will be advised without further notice being given.

The regulations then describe what shall be done in case of accident. This is treated of under two heads:

(a) Measures to be taken in the case of an explosion of gas or coal-dust or of a pit-fire.

(b) Measures to be taken in the case of a shaft-fire.

Germany

In Germany the mines are under the control of the district officers, the superior mine offices, and the Minister of Commerce and Trade. The inspectors are under the district officers. They are authorized to call the attention of the employees of the mining company to certain offences against the mining police regulations and to other bad conditions, and to discuss improvements with them. Superior to the district officers are the superior mine offices, to which are delegated the powers of the government within the territory.

Up to 1907, the provision of mine rescue appliances was not generally compulsory, but, in all the collieries in certain districts of Germany, mine rescue apparatus was installed and men were regularly trained in their use. At the present time, most of the districts in Germany have provisions relating to mine rescue equipment.

Great Britain

In considering the question of compulsory mine rescue equipment, the British Royal Commission on Mines, in their first report issued in 1907, state that "after fully considering the results of experience here and abroad, we are of the opinion that the question is ripe for further development in this country, and demands the serious attention of the industry. We have considered whether it would be desirable to make the provision of any of these appliances compulsory, and we have come to the conclusion that sufficient advance has not been made in this country to justify such a course at present." Between 1907 and the time of issuing the last report, 1909, many private mine-rescue stations were erected.

The last report states in part:

> "The point, however, on which we wish to lay stress is the need for greater activity in the establishment of stations and the training of men, and in the testing of the different types of apparatus with a view to securing their greater perfection. We hope that the progress made in the immediate future in the different districts will render it unnecessary for the Government to make statutory regulations, as it appears to us that for the present the matter can best be dealt with by voluntary organization. Ultimately, when more extensive experience has been gained, it may be desirable to lay down some general requirements as to the provision of appliances and the training of men."

The Rescue and Aid Order

In 1912, the Rescue and Aid Order* made provision for these latter requirements. The following is a brief résumé of the Order:

> In pursuance of Section 1 of the Mines Accidents Rescue and Aid Act, 1910, I hereby make the following Order:
>
> (1) This Order shall apply to all mines in which coal is worked, provided, however, that the Secretary of State may, if he thinks fit, exempt from the Order any mine at which the total number of

* Order dated April 2, 1912, made by the Secretary of State under section 1 of the Mines Accidents Rescue and Aid Act, 1910, (10 Edw. VII and 1 Geo. V, c. 15).

underground employees is less than 100 if the mine is so situated that in the opinion of the Secretary of State the organization of a Central Rescue Station from which it could be served, is impracticable.

(2) No person, unless authorized by the Manager or official appointed by the Manager for the purpose, or, in the absence of the Manager or such official, by the principal official of the mine present at the surface, shall be allowed to enter a mine after an explosion of fire-damp or coal-dust, or after the occurrence of a fire, for the purpose of engaging in rescue work.

(3) (a) There shall be organized and maintained at every mine, as soon as is reasonably practicable, competent rescue brigades on the following scale:

Where the number of underground employees is 250 or less	1 brigade
Where the number of underground employees is more than 250 but not more than 700	2 brigades
Where the number of underground employees is more than 700 but not more than 1,000	3 brigades
Where the number of underground employees is more than 1,000	4 brigades

But the Owner, Agent or Manager of a mine, at which the total number of underground employees is less than 100, shall be deemed to have complied with this provision if he has acquired the privilege of calling for a brigade from a Central Rescue Station.

A group of mines belonging to the same owner, of which all the shafts or exits, for the time being in use in working the mines, lie within a circle having a radius of two miles shall, for the purpose of ascertaining the number of brigades required, be treated as one mine.

(b) A rescue brigade shall consist of not less than five persons employed at the mine, carefully selected on account of their knowledge of underground work, coolness and powers of endurance, and certified to be medically fit, a majority of whom shall be trained in First Aid and shall hold a Certificate of the St. John's Ambulance Association or of the St. Andrew's Association.

(c) There shall be selected from the ranks of each rescue brigade one person or leader who shall act as captain of the brigade.

(d) A brigade shall not be deemed competent unless (i) it

undergoes a course of training approved by the Secretary of State; (ii) after the preliminary course of training it undergoes in every quarter at least one day's practice with breathing apparatus, which practice shall at least twice in the year take place at the mine; (iii) the members of the brigade shall have received instruction in the reading of mine plans, in the use and construction of breathing apparatus, in the properties and detection of poisonous or inflammable gases, and in the various appliances used in connection with mine rescue and recovery work.

(e) Arrangements shall be made at every mine for summoning members of rescue brigades immediately their services are required.

(4) If it can be clearly proved that the necessary number of persons employed underground at a mine will not consent to form a brigade or brigades, or having offered their services fail to be trained or maintain their training, the Owner, Agent or Manager of the mine shall not be liable to any penalty provided first that he has endeavoured to the best of his ability to constitute the requisite brigade or brigades, and has afforded every opportunity to the persons employed at the mine to undergo the necessary training, and secondly that he has made a bona fide attempt to arrange for the supply from a Central Rescue Station of such rescue brigades as he is unable to provide at his mine.

(5) (a) There shall be provided and maintained at every mine suits of portable breathing apparatus in the proportion of two suits to each brigade required by section 3 (a). The apparatus must be capable of enabling the wearer to remain for at least one hour in an irrespirable atmosphere, and must be kept ready for immediate use. The apparatus must be housed in suitable receptacles in a dry and cool room.

The Owner, Agent or Manager of a mine shall be deemed to have complied with this requirement if he has acquired the privilege of calling for such of these appliances as he may not possess from a Central Rescue Station, always provided that the Central Rescue Station is situated within a radius of 10 miles from the mine and is in telephonic communication with the mine.

If it can be shown that it is not possible, at the date of this Order, to procure the aforesaid breathing appliances, owing to lack of supply, the Owner, Agent or Manager shall be deemed to have complied with this Order if he procures such appliances as soon as is reasonably practicable.

(b) There shall be kept at every mine tracings of the workings of the mine up to a date not more than three months previously, showing the ventilation and all principal doors, stoppings and air crossings and regulators, and distinguishing the intake air by a different colour from the return air, which tracings shall be in a suitable form for use by the brigades.

(c) There shall also be provided and maintained at every mine which maintains a rescue brigade or brigades—

(i) Two or more small birds or mice for testing for carbon monoxide.

(ii) Two electric hand-lamps for each brigade, ready for immediate use and capable of giving light for at least four hours.

(iii) One oxygen reviving apparatus.

(iv) A safety lamp for each member of the rescue brigade for testing for fire-damp.

(v) An ambulance box provided by the St. John's Ambulance Association or similar box, together with antiseptic solution and fresh drinking water.

(6) There shall be kept and maintained in every Central Rescue Station not less than 15 complete suits of breathing apparatus, with means of supplying sufficient oxygen or liquid air to enable such apparatus to be constantly used for two days, and of charging such apparatus; and

20 electric hand-lamps;

4 oxygen reviving apparatus;

An ambulance box or boxes, provided by the St. John's Ambulance Association, or similar boxes, together with antiseptic solution and fresh drinking water;

Cages of birds.

A motor car shall be kept in constant readiness.

(7) Every Central Rescue Station shall be placed under the immediate control of a competent person conversant with the use of the appliances.

(8) There shall be adopted at every mine by the Owner, Agent or Manager such rules for the conduct and guidance of persons employed in rescue work in or about the mine as may appear best calculated for the carrying out of rescue operations,

and the rescue brigade or brigades, if any, maintained at the mine shall be thoroughly instructed in such rules.

(9) "Central Rescue Station" means a station established to serve several collieries.

R. McKenna
One of His Majesty's Principal
Secretaries of State

Home Office, Whitehall,
2nd April, 1912

United States

Prior to 1908, little progress in the adoption of breathing apparatus at mines had been made in the United States. At that time, there were only a few sets of modern apparatus in the whole country. Since then, the use of the apparatus by the Technologic branch of the United States Geological Survey and by the Bureau of Mines, which is carrying on the mine-accident investigations begun by the Geological Survey, has awakened wide-spread interest and has called attention to the value of the apparatus in fighting mine fires and in exploring mines after explosions. In consequence, a number of the largest coal-mining companies in this country have voluntarily purchased breathing apparatus and have established training stations. As the regulation of mines is a function of the State governments, the Bureau of Mines has no authority to require other operators in the several coal-mining states to take similar action.

Mine-rescue Training

The Bureau of Mines has established a regular course of training in the use of mine-rescue breathing apparatus. It is designed to give miners and other persons connected with mining, a knowledge of breathing apparatus in general, and a familiarity with the types of apparatus that are most apt to be used in this country.

The purpose of the Bureau of Mines, in establishing this system of training, is to facilitate investigative work within mines in which disasters have occurred, and to make mine owners and miners acquainted with the value of breathing apparatus for rescue operations after mine disasters. As a result of this work by the Federal Government, it is hoped that, in the near future, men familiar with such apparatus will be scattered throughout the coal-mining centres of the country, and be available on short notice to assist in rescue operations. After a disaster, valuable time is often lost in training men at the mine before rescue parties can

be organized. Furthermore, a man can not work efficiently unless he has thorough confidence in the apparatus. To give a man this confidence, the course of training has been planned in such a way that he must do work in poisonous or unbreathable gases for periods of one and two hours at a time.

Training with Breathing Apparatus

The Bureau has five mine-accident investigation stations already established and one in course of construction, as well as seven training cars. The stations are at Pittsburg, Pa.; Urbana, Ill.; Knoxville, Tenn.; Seattle, Wash.; and McAlester, Okla. The one under construction is at Birmingham, Ala. The Government foremen, in charge of the stations and cars, give instruction in the use of breathing apparatus and are always ready to meet State inspectors or officials of mining companies who may ask advice or aid in planning rescue-training stations or courses of instruction.

At the Pittsburg station various types of apparatus are on exhibition and may be used in training work by miners. At the sub-stations and cars, either Draeger, Westfalia, or Fleuss (Proto) apparatus are on hand.

In the training work at sub-stations and cars, other types of apparatus are described by the foreman in charge of training work, but only those parts of the following programme, which apply to the use of the apparatus on hand, are followed. Each of items (c), (e) and (g) covers two periods of one hour. This rule applies whether one type or more than one type of apparatus is on hand.

(a) The student is instructed in the construction of each apparatus, the method of wearing it, the system of circulation, and the source of the breathable air it supplies.

(b) Full explanation respecting charging and testing the apparatus is given, the student being required to perform the work of recharging and testing.

(c) The student selects two types of apparatus (if more than one type is on hand) in which he desires to receive special training. Without turning on the oxygen, he wears each of these for one hour in fresh air. While wearing an apparatus, he walks at an increasing gait and finally runs for a few minutes, saws off ends of props, carries brick, operates a work (weight-pulling) machine, and crawls through narrow passageways.

(d) Each of the types of apparatus on hand is worn in the same way as under (c), but having the oxygen turned on.

(e) With each of the apparatus selected for special training work, the student enters the gas chamber and performs, as nearly as the construction of the chamber will allow, Schedule No. 1, in an atmosphere containing sulphur dioxide or formaldehyde gas. Each test is one hour long, thus requiring a total of two hours to complete the work of the test.

(f) All other types of apparatus on hand are worn for 15 minutes each; the work consists alternately, of pulling a weight machine and of walking over the overcast, in an atmosphere made unbreathable by sulphur dioxide or formaldehyde gas.

(g) The student enters the gas chamber and performs, with each of the apparatus selected for special training work, Schedule No. 2, in an atmosphere containing sulphur dioxide or formaldehyde gas, each test continuing for two hours without intermission. The temperature of the atmosphere in the room does not exceed 85°F., wet bulb. Schedule 2 is repeated, if necessary, a sufficient number of times to insure the student having full confidence in the use of the apparatus in unbreathable gases.

(h) The different types of apparatus for reviving persons overcome by gas are fully explained and their use demonstrated upon the student. Information is given on the organization of rescue parties for underground service.

A physical examination of the student is made by the foreman in charge at some time during the course of training when the student feels normal.

At such places as do not have a regularly equipped training station, the equivalent of this course of training is accomplished within a mine or in a building where the atmosphere may be fouled with smoke or fumes.

Schedule No. 1

(1) Walk 10 laps, equal to one-fifth of a mile.

(2) Carry six props over overcast and wedge up under collars.

(3) Carry brattice cloth over overcast and stretch up at place designated.

(4) Load 10 bricks in a gunny sack, carry over overcast, and return to point where found.

(5) Saw four pieces off a log or prop.

(6) Take down brattice and return to point where found.

(7) Take down props and return to point where found.

(8) Alternate pulling weight-machine 50 times and walking five laps until the hour is completed.

Schedule No. 2

(1) Walk 20 laps, equivalent to two-fifths of a mile.

(2) Carry 12 props over overcast and wedge up under collars.

(3) Carry brattice cloth over overcast and stretch up at place designated.

(4) Carry dummy over overcast on stretcher and leave at point found. (If only one man is training, the foreman in charge will put on an apparatus and assist in carrying dummy).

(5) Carry 25 bricks in a gunny sack over overcast and build a wall.

(6) Take down props and brattice cloth and return to point where found.

(7) Crawl through small tunnel twice.

(8) Alternate pulling weight-machine 50 times and walking five laps until two hours are completed.

The course of training with breathing apparatus may be completed in a week or ten days. At the end of the training the student is given a certificate, with a statement of such work as he has performed. His name and record are kept on the files of the bureau.

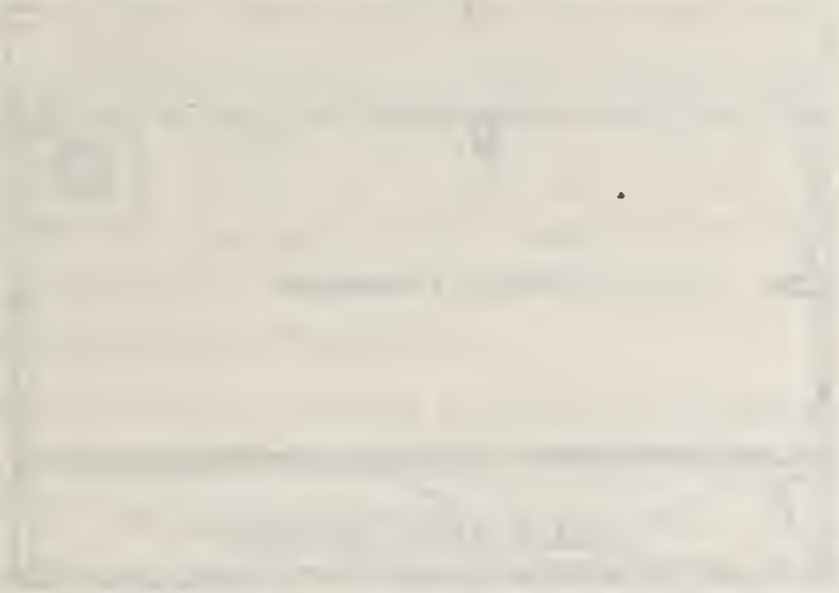
CANADA

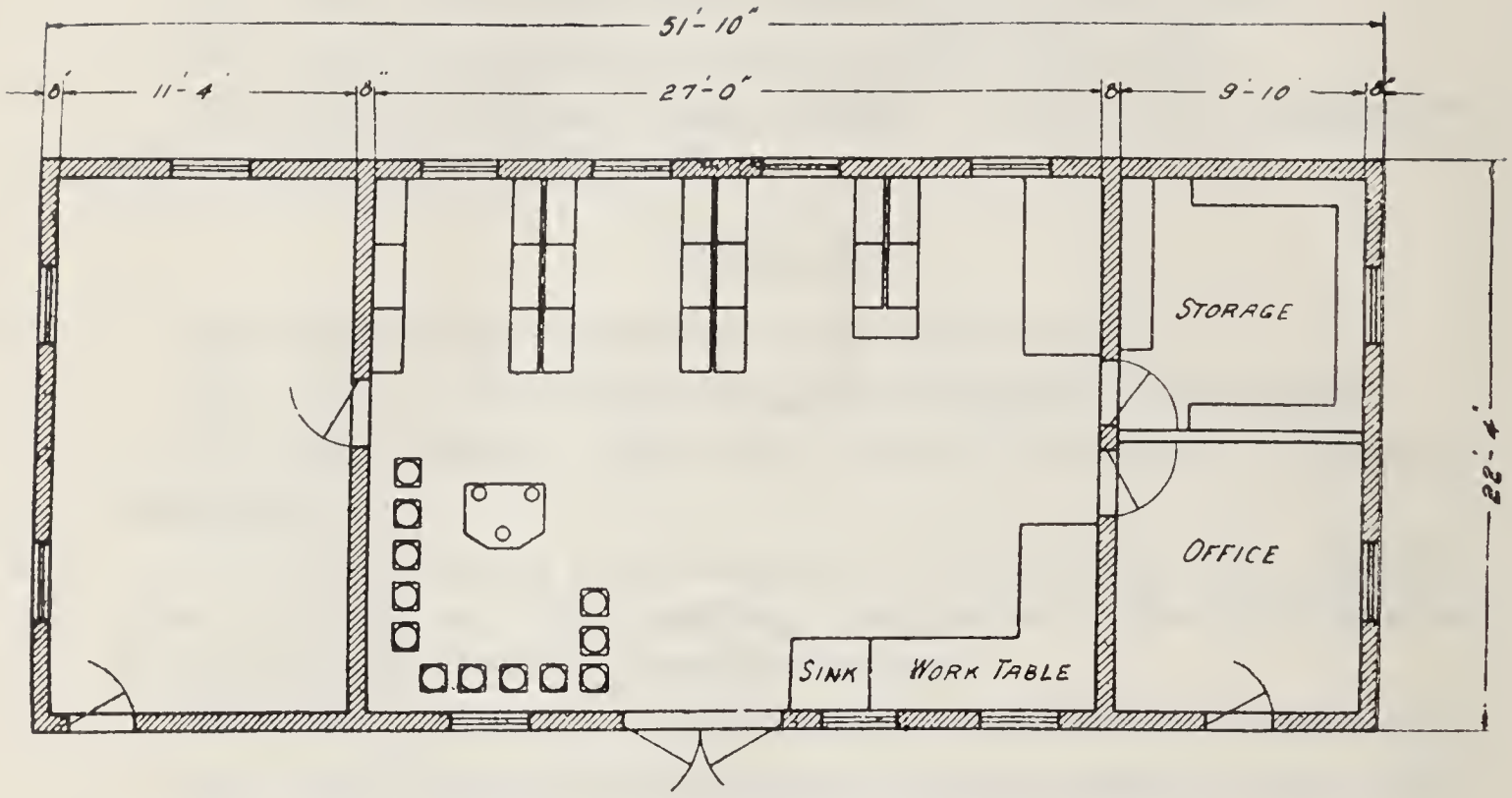
In Canada, as regulation of mines is a function of each province, the Federal Government has no authority to require operators in the several coal-mining provinces to make provision for mine-rescue apparatus. Neither has the Federal Government carried out any demonstration work in the use of such apparatus. Of the coal-producing provinces, British Columbia is the only one that requires rescue apparatus to be kept at coal mines.

The following is a short account, by provinces, of the nature and extent of mine-rescue work in Canada.

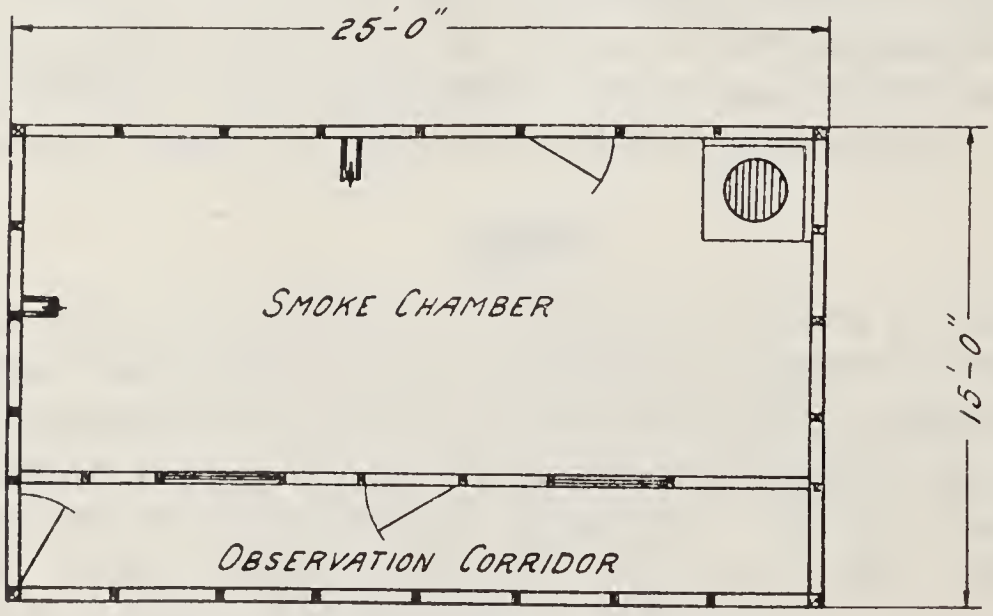
Nova Scotia

There are no government rescue stations in this province, nor is there any statutory provision for compulsory mine-rescue training





PLAN OF CENTRAL RESCUE STATION, SHOWING APPARATUS ROOM AND EMERGENCY HOSPITAL



PLAN OF SMOKE CHAMBER

By Courtesy of F. W. Gray, Dominion Coal Company

and equipment at coal mines. Nevertheless, a number of the most important mines have well equipped rescue stations and a large body of men trained in the use of breathing apparatus.

Dominion Coal Company*.—The Dominion Coal Company, have in the past, suffered severe losses through fire, both above and below ground. In 1903, a fire occurred in Dominion No. 1 mine, and, in 1906, a fire broke out in the pit bottom of the Hub colliery. In both cases, the mine had to be flooded before the fire could be extinguished. In order to guard against similar possible occurrences, an efficient fire fighting organization and equipment were established. Only that portion of the equipment and organization which relates to breathing apparatus will be considered in this description.

In 1908, the Central Rescue station was constructed and equipped near No. 2 colliery. Its central position in relation to the surrounding mines, indicated it as the most desirable. When erected, this station was, with the exception of the United States Government station at Pittsburg, the only one of its kind on the North American continent. It is a substantial brick building,† with concrete floor, and contains four rooms, viz.: main or apparatus room, emergency hospital and dressing room, office and store-room.

The equipment consists of thirty-six Draeger apparatus, forty-two electric hand-lamps, one Bratt resuscitating apparatus, one pulmotor, one electrically-driven oxygen-refill pump and one hand-power oxygen-refill pump, one Koenig smoke-helmet, one wheel stretcher with oxygen flask and mask complete for bringing injured men out of an irrespirable atmosphere, and a sufficient supply of oxygen and potash cartridges. The electric hand-lamps are charged at the station and kept always ready for use. The station is connected by telephone, with all the collieries and with the instructor's residence.

One end of the rescue station is fitted up as an emergency hospital and dressing room. It contains a wash-basin, spring couch, table and rubber sheet. First-aid requisites, blankets, stimulants, etc., are also kept on hand. In addition to the ordinary stock in the store-room, eight canaries are also kept available for the purpose of testing for carbon monoxide during mine-rescue work.

Adjoining the station is a smoke chamber where the men are trained

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* In this description of the mine-rescue equipment of the Dominion Coal Company, free reference has been made to the article on "The Fire Fighting Organization and Equipment" of these collieries, written by F. W. Gray, Assoc. M. Inst. M.E., and published in the Canadian Mining Journal.

† See illustration facing p. 21.

to work in an irrespirable atmosphere. This is a rough, wooden shed, consisting of an observation corridor divided from the main building by a partition with glass windows. The smoke chamber proper* has no windows, and has a fire grate in one corner in which materials are burned to make a dense smoke. For exercising the men during training, there are two weight-lifting machines, consisting of a rope passing over a pulley and attached to a forty-five pound weight.

Men training in the use of breathing apparatus, enter the smoke room wearing the apparatus and carrying electric lamps. After performing a certain amount of work, each man is examined as to his behaviour under physical strain and his suitability for this class of work is thus determined.

In addition to the apparatus at the Central station, auxiliary apparatus are kept at some of the outlying collieries. These are intended for use by the colliery rescue corps pending the arrival, if necessary, of a detachment from the Central station.

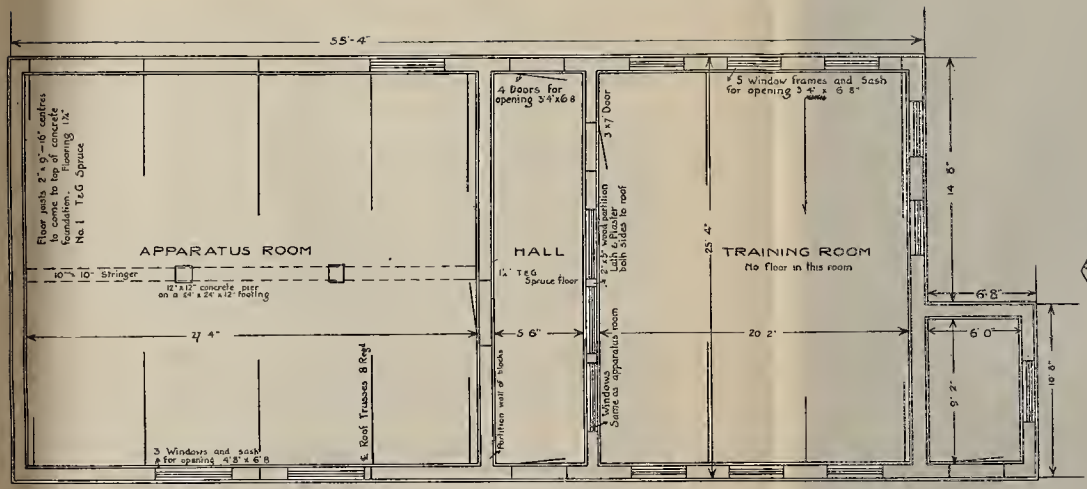
Each colliery has either two or three rescue corps, consisting of men who are resident at the colliery and acquainted with the workings. These men are chosen because of their knowledge of the underground workings, ventilation and position of the air roads, pipe lines and connections. A necessary preliminary to their selection is that they must be passed upon by the instructor as being suitable for the work. The names of the men composing the corps and the period for which they are detailed for duty are posted in the firemen's hall, near the apparatus. As far as possible, the corps are arranged in such a way that the trained men at one colliery shall not all be underground at the same time.

The instructor makes periodical visits to all the collieries having rescue apparatus and exchanges the colliery apparatus for others from the Central station. This is done in order that the apparatus may always be in good working order.

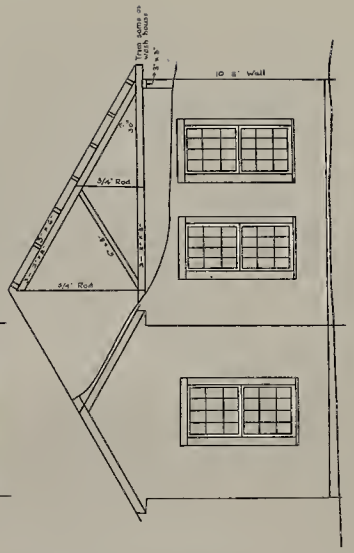
The company intends, also, to install a sub-rescue station at New Waterford to serve the Lingan collieries. This equipment is to consist of ten Draeger apparatus with spare oxygen cylinders, one hand-power oxygen-refill pump and one pulmotor. It is also the intention of the company to install a rescue station at the Springhill collieries. It will consist of ten apparatus, one refill pump and one pulmotor together with the necessary oxygen tanks and accessories.

The company has now a large number of men trained in the use of the apparatus. It has been successfully used on several occasions,

* See illustration facing p. 21.


55'-4"
Floor joists 2"x 8"—16" centres to come to top of concrete foundation. Flooring 1¼" No. 1 T&G Spruce
APPARATUS ROOM
10" Stringer
12"x12" concrete pier on a 64"x24"x12" footing
27' 4"
3 Windows and sash for opening 4'8"x6'8
6 Roof Trusses 8 Rod
4 Doors for opening 3'4"x6'8
HALL
1¼" T&G Spruce floor
5'6"
Partition wall of blocks
3'x7' Door
3'-2½" wood partition Lath & Plaster both sides to roof
3 Windows Same as apparatus room
5 Window frames and Sash for opening 3'4"x 6'8"
TRAINING ROOM
No floor in this room
25' 4"
20' 2"
14' 8"
6'8"
6'0"
9'2"
10'8"

FLOOR PLAN
Scale ⅛" = 1 foot



SIDE ELEVATION

Note This Building to be built of 8"x 8"x 16" building blocks with cement mortar joints. 1 part cement of approved brand 3 parts clean sharp sand - Blocks to be laid with glazed side out and true to line - All Joints to be bedded in a thorough manner Window and door frames to be fastened to blocks with wood fillers and blocks, to have inside and outside Trim - well bedded in cement Roofed with "Rubberoid" or "Paroid" 3 ply roofing paper

ALBION MINE - RESCUE STATION
Scale ⅛" = 1 Foot
C A M.

By Courtesy of the Acadia Coal Co.

PLAN OF ALBION MINE-RESCUE STATION, ACADIA COAL CO.

notably at Sydney Mines and at Stellarton. Apart from the rescue work, there are a number of men trained in first-aid and ambulance work, there being properly fitted ambulances to serve all the collieries.

Acadia Coal Company.—This company has a training station in which the men are instructed in the use of portable breathing apparatus. The station* consists of a building 20 feet by 40 feet, in which the apparatus is installed and lessons are given in its use in a breathable atmosphere. The smoke room, where the men test the apparatus before going into the mine, is about the same size as the station. The company intends to place a number of obstacles in the smoke room to simulate the interior of a mine, so that the men may be trained under conditions similar to those that exist underground.

The equipment consists of ten helmet type Securitas apparatus, each with two hours' oxygen supply attached; ten electric hand lamps, one oxygen-refill pump, one Bratt resuscitating apparatus, and a sufficient supply of oxygen and absorption cartridges.

The rescue corps are made up of six men each. It is planned to give each corps a complete course of training—consisting of ten lessons—immediately after volunteering, and, then, have them meet once a month that they may be kept familiar with the apparatus and be able to answer a call instantly.

Nova Scotia Steel and Coal Company.—This company has a rescue, fire and first-aid station. It was formerly in a room in the general office building, but is now in a railway car. This car is always held in readiness to go to any of the collieries owned by the company or to any colliery in the province with which rail connections can be made. It is an ordinary passenger car and is divided into three sections.†

Car Section No. 1.—This section is fitted and furnished for the accommodation of the rescue crew.

Car Section No. 2.—This section is fitted with:

16 sets of rescue apparatus
24 oxygen cylinders
2 oxygen-refill pumps
1 pulmotor
2 dozen electric safety lamps
1 electric charging device for charging electric lamps
1 Draeger oxygen reviving trunk

* See plan facing p. 23 and illustration facing p. 24.

† See plan facing p. 25 and illustration facing p. 26.

6 ordinary respirators
Blue print plans of all the colleries
1 set of portable telephones
Canaries for gas testing purposes

Other accessories which are necessary in the event of a mine explosion, are also stored in the car. Section 2 also contains stretchers, splints, oil, restorators, and drugs of all kinds which might be necessary in case of accident.

Car Section No. 3.—This section contains fire reels, hose, fire buckets, ladders, axes, saws, fire extinguishers and all the necessary equipment for use in case of fire. The car is furnished with blankets, cooking stove, and all articles necessary to enable the crew to live on board the car for short periods of time.

The types of rescue apparatus used are, fifteen of the Draeger helmet-type and one of the Ever-Ready mouth-piece type. These have an oxygen capacity for about two hours' effective work.

Of the twenty-four oxygen cylinders, only seven are carried in the car, the others being stored as an emergency supply. The capacity of these cylinders is 100 cubic feet of oxygen at a pressure of 125 atmospheres. In connection with the breathing apparatus, a smoke house is constructed for the purpose of giving the men practice in using the apparatus in an irrespirable atmosphere. The smoke house is centrally situated and is built in such a way that while they are at work in the unbreathable atmosphere, the men can be observed by the head trainer from the passage way.

There are at present about forty men, including all the officers in connection with the collieries, who are trained in the use of the rescue apparatus. In addition to this number, twenty-four officers of the company hold certificates of proficiency in giving first-aid to the injured, granted by the St. John's Ambulance Association.

In connection with this work there are also ambulances, stretchers and blankets at each colliery, while in the rescue car there is a first-class ambulance fully equipped with every convenience for the conveyance of injured men from the car to the hospital or their homes.

Alberta

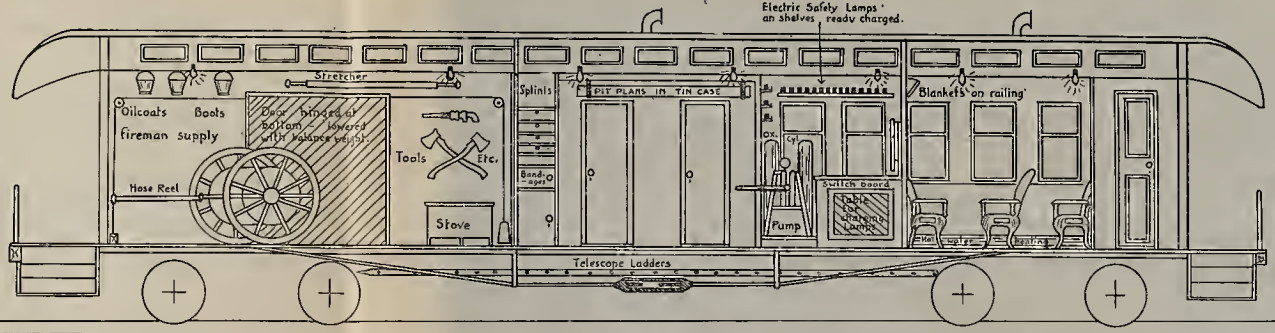
In this province, no statutory provision is made for compulsory mine-rescue training and equipment at coal mines. The opinion seems to be that it is better to have one or more central stations with officials

By Courtesy of Acadia Coal Co.

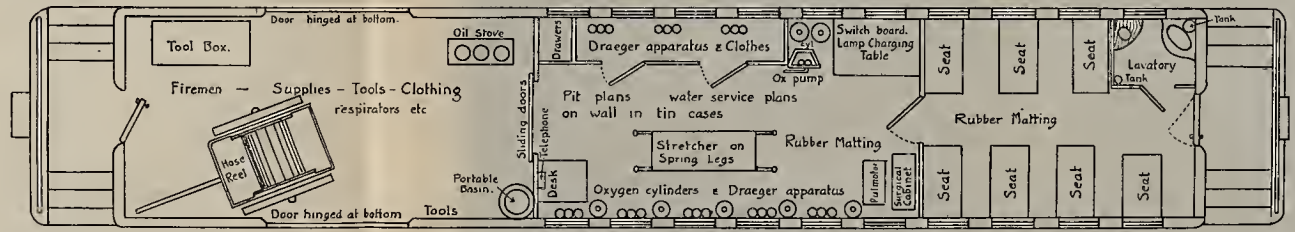
ALBION MINE-RESCUE STATION, ACADIA COAL CO., STELLARTON, N.S.

By Courtesy of Acadia Coal Co.

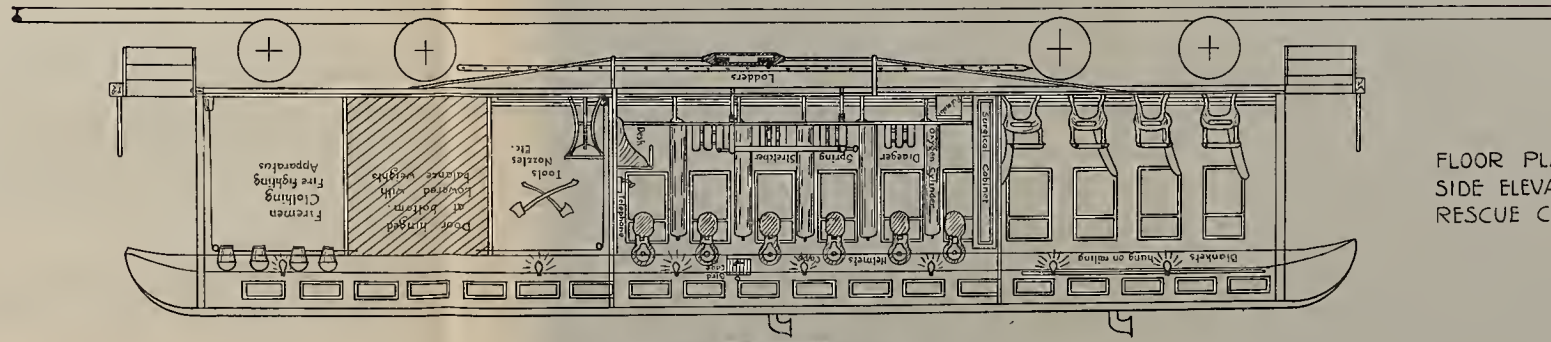
ALBION APPARATUS ROOM, ACADIA COAL CO., STELLARTON, N.S.



SIDE ELEVATION



FLOOR PLAN



SIDE ELEVATION

PLAN OF RESCUE CAR, NOVA SCOTIA STEEL & COAL CO.

Scale, 1 Inch = 6 Feet

FLOOR PLAN & SIDE ELEVATION of RESCUE CAR

By Courtesy of Nova Scotia Steel & Coal Co.

in charge of the stations who will be responsible for the upkeep of the apparatus.

At present, there is only one mine-rescue station in Alberta. This is a temporary station situated at Blairmore and is available for all the mines in the Crowsnest Pass district. An additional rescue station is now being erected at Lethbridge and, in a short time, a third will be established at Kipp. The Blairmore station has only been in operation since March, 1912. One-half of the cost of the equipment and operation of this station will be borne by the Government of Alberta, and one-half by the different operators in the district. It is expected that, within a short time, a railway car will be fitted up with rescue apparatus and moved from mine to mine.

The station in use at present consists of three rooms, each 24 feet by 14 feet; the apparatus is kept in one; another room is fitted up as an office and lecture room; and the third is a smoke chamber.

The station is under the charge of a superintendent holding a mine manager's certificate. The training, which occupies six days, is divided into the following sections:

First day—Description of apparatus by Superintendent and taking apart and putting together of apparatus by persons being trained.

Second day—Lecture on apparatus for one hour and wearing of apparatus in smoke chamber for one hour.

Third day—Wearing of apparatus in mine for one and a half hour and further lecture on apparatus.

Fourth day—Wearing of apparatus in mine and in smoke chamber for two hours.

Fifth day—Wearing of apparatus in mine for two hours.

Sixth day—Wearing of apparatus in mine for one and a half hour, and in smoke chamber one hour.

This training is varied slightly according to the discretion of the Superintendent. While in the smoke chamber, a considerable amount of work is done in sulphur smoke, such as building stoppings, putting up and taking down brattice, and general work as nearly as possible similar to that which would be required to be done in a mine during rescue work.

While in the mine, the wearers of the apparatus travel up a roadway pitching about 40 degrees, for a distance of about 450 feet and come out at the surface. The authorities have not yet decided upon the exact

routine of training work and may vary this considerably. After a man has gone through six days' training, it is the intention to bring him back at the end of three months to undergo another training, and again, at the end of a further three months, after which he will, if judged to be satisfactory, be granted a certificate showing that he is capable of doing rescue work in a mine after an explosion.

Primarily, the training work has been considerably handicapped by the difficulty in obtaining a sufficient supply of oxygen and soda. In order to overcome this, however, it is the intention to carry on hand a stock of 3,000 cubic feet of oxygen at a pressure of 120 atmospheres, and 1,500 lbs. of caustic soda.

At this station there are eleven Fleuss apparatus of the two-hour type and six of the one-hour type. This will probably be increased to fifteen of the two-hour type and ten of the one-hour type.

British Columbia

The Coal Mines Regulation Act, 1911, makes provisions for rescue apparatus at mines, as follows:

"There shall be established by the owner, agent or manager of every colliery such number of oxygen helmets or some form of mine-rescue apparatus as may be approved by the Minister of Mines.

"Such mine-rescue apparatus shall be constantly maintained in an efficient and workable condition, and shall in all cases be so stored or placed in or about the mine as to always be available for immediate use.

"The Lieutenant-Governor in Council may from time to time establish mine-rescue stations for the purpose of supplementing, in case of need, the colliery installations of mine-rescue apparatus, and also for the purpose of training the holders of certificates of competency under this Act in the use of such mine-rescue apparatus as may be approved by the Minister of Mines; and it shall be incumbent on the owner, agent, or manager of every operating mine to have all certificated officials who are physically fit, and not less than three per cent. of such number as the Chief Inspector of Mines may deem sufficient, of the workmen, trained in the use of such established mine-rescue apparatus:

"Provided that in cases of emergency such stations shall be available for the use of any trained corps of mine-rescuers, duly

By Courtesy of Nova Scotia Steel & Coal Co.

RESCUE CAR AND RESCUE CORPS, NOVA SCOTIA STEEL & COAL CO., SYDNEY MINES, N.S.

qualified medical practitioners, or corps trained in the work of first aid to the injured, subject, always, to the order of an Inspector of Mines."

Although this act has only been in force a little over a year, the operators, as well as the Government, are doing all in their power to lessen the number of fatalities incident to mine explosions and mine fires in so far as this can be accomplished by trained men equipped with suitable breathing apparatus.

The Government of British Columbia has secured sites for rescue stations at Fernie, in the Crowsnest district, and at Nanaimo, Vancouver island. Tenders have been called for the erection of the buildings and they will be completed at an early date. The illustration facing page 28 shows the plan and elevation of these buildings.

The Government owns the following apparatus:

14 sets of two-hour, 1910 model, helmet-type Draeger apparatus

8 sets of one-half hour, mouth-breathing type Draeger apparatus

4 pulmotors

4 oxygen pumps

42 oxygen tanks, of 100 cubic feet capacity each

14 electric safety lamps, together with all necessary accessories and spare parts.

They have also under order* two sets of two-hour, 1911 model, mouth-breathing type Draeger apparatus and sufficient material to convert the present 14 sets of 1910 model, helmet-type into mouth-breathing type. These apparatus will thus be available either as helmet or mouth-breathing apparatus. Two stretchers equipped with oxygen breathing apparatus and 16 trunks for storing and shipping the apparatus, are also on order.

The present distribution of this apparatus is as follows:

NANAIMO:

4 sets of two-hour apparatus

2 sets of one-half hour apparatus

1 pulmotor

12 oxygen tanks

1 oxygen pump

4 electric safety lamps

* June 11th, 1912.

CUMBERLAND:

4 sets two-hour apparatus
2 sets one-half hour apparatus
1 pulmotor
12 oxygen tanks
1 oxygen pump
4 electric safety lamps

HOSMER:

4 sets two-hour apparatus
2 sets one-half hour apparatus
1 pulmotor
14 oxygen tanks
1 oxygen pump
4 electric safety lamps

MIDDLESBORO:

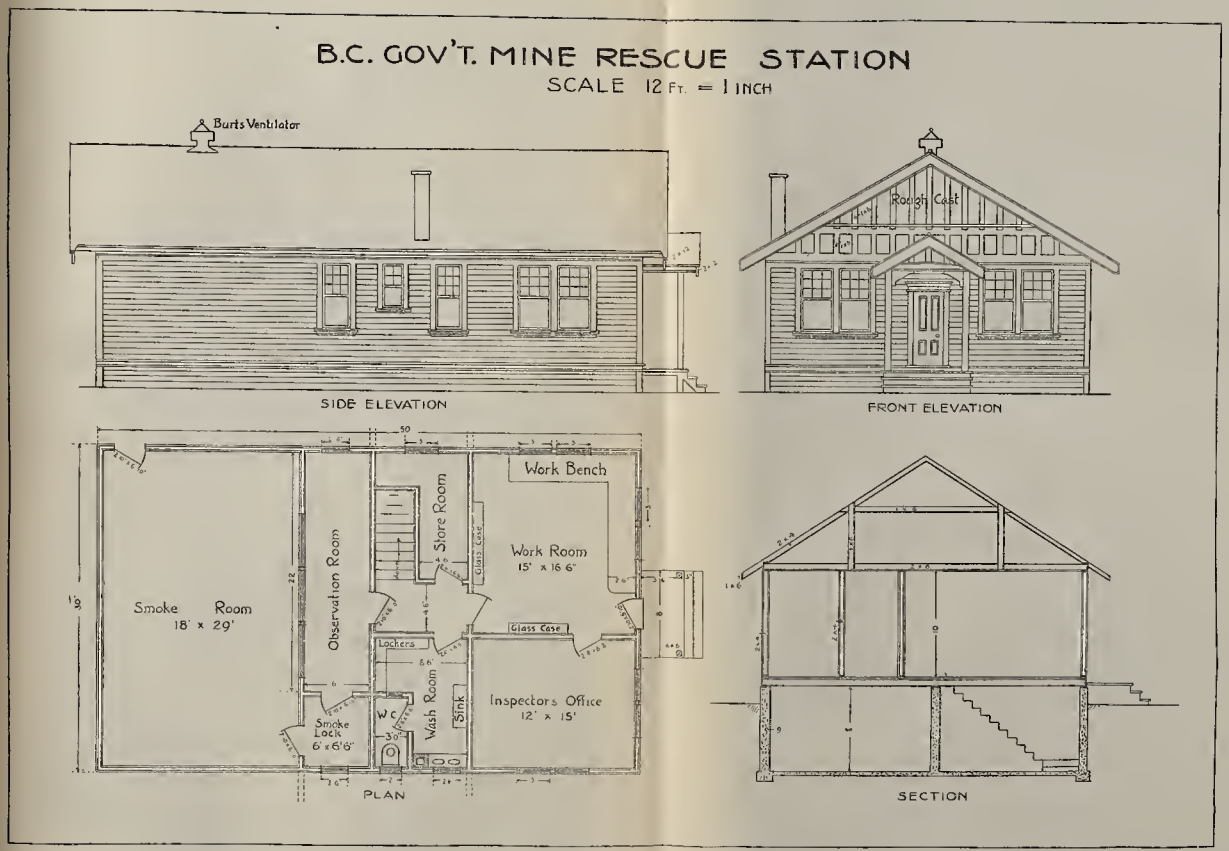
2 sets two-hour apparatus
2 sets one-half hour apparatus
1 pulmotor
4 oxygen tanks
2 electric safety lamps

This apparatus is supplementary to the equipment of the coal companies and at present is taken care of by the Western Fuel Company, at Nanaimo; the Canadian Collieries (Dunsmuir), Ltd., at Cumberland; the Hosmer Mines, Ltd., at Hosmer, and the Nicola Valley Coal and Coke Co., Ltd., at Middlesboro.

MINING COMPANIES AND THEIR EQUIPMENT.—All the operating companies own, or have on order, oxygen apparatus of some type, and some companies own very creditable stations for training purposes.

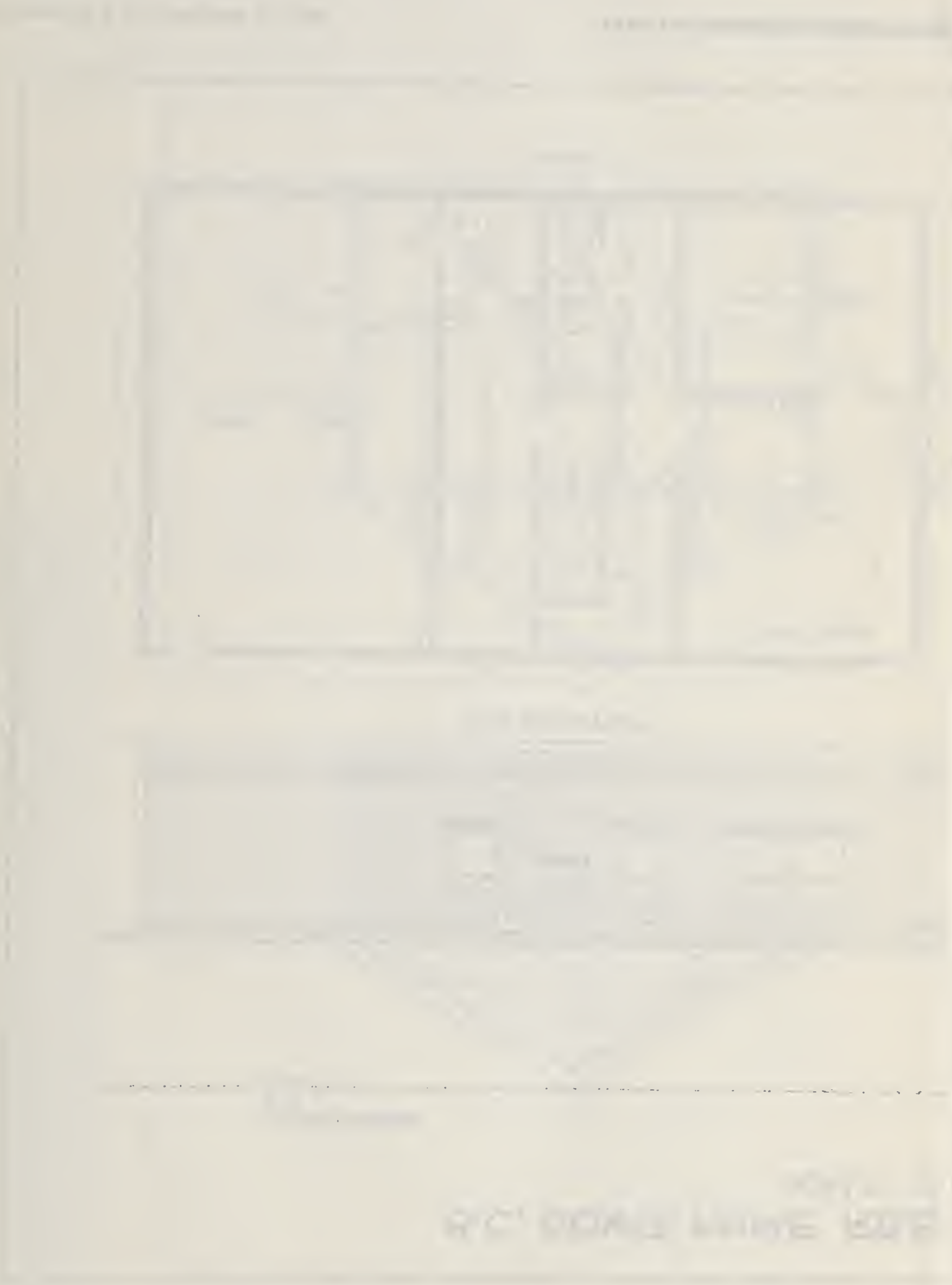
Western Fuel Co., Nanaimo.—This company erected the first station in the province. It was opened in the autumn of 1910, and, since that time, 62 employees of the company have taken a course of training in it and have been awarded certificates of competency. These employees have been formed into 12 corps.

This company's station is of frame construction on concrete foundation and is covered with corrugated iron. The inside is finished in hard wall plaster, its dimensions being 24 feet by 48 feet. It consists of a smoke room and work room, the latter containing the cases for the apparatus.



By Courtesy of B. C. Department of Mines

PLAN OF RESCUE STATION, GOVERNMENT OF BRITISH COLUMBIA.



By Courtesy of Western Fuel Co.

RESCUE STATION AND RESCUE CORPS, WESTERN FUEL CO., NANAIMO, B.C.

The apparatus consists of

4 sets two-hour, 1907 model, helmet-type Draeger apparatus
4 sets two-hour Fleuss (Proto) mouth-type
3 sets one-hour Fleuss (Salvator) mouth-type
1 pulmotor
12 oxygen tanks
1 oxygen pump
4 electric safety lamps (Draeger type)
6 electric safety lamps (Fleuss type)

The work necessary to obtain a certificate consists in becoming familiar with the principle and construction of the apparatus, in assembling and dissembling the same and in the use of the pulmotor.

Then a team of four men must perform the following two-hour schedule of work not less than seven times, in the smoke room filled with either sulphur or formaldehyde fumes:

1—15 laps around the smoke room, travelling over the overcast and crawling through the tunnel, which is 3 feet high and 4 feet wide.

2—Hang 8 yards of brattice cloth over the overcast, and erect 4 yards of board brattice in the tunnel, all material being brought over the overcast.

3—Make 10 laps around the smoke room over the overcast and through the divided tunnel, take down the board and cloth brattice, placing it where found.

4—Each pair of men to carry a dummy on stretcher, weight 150 lbs., twice around the smoke room, over the overcast and through the tunnel, using both the Sylvester method and Draeger pulmotor for resuscitation purposes.

5—Erect a board regulator in the centre of the tunnel area 18 inches by 18 inches, each pair of men to take the dummy without the stretcher once around the room over the overcast and through the regulator; then each member of the corps to make 10 laps without the dummy.

6—Take down the regulator and erect in the middle of the tunnel a brick stopping 1½ bricks thick, carrying all material over the overcast. Take down stopping, carrying material back to place where found and piling up neatly.

7—The top of the tunnel is then raised against the wall to prevent crawling, and as many laps made around the smoke room and over the overcast as can be made within the two-hour limit.

A record is kept of each man's work, including amount of oxygen upon entering, and upon coming out, length of time in the smoke room, and his general condition when he comes out.

The lamp used is either Wolf safety lamp or Electric safety lamp. Each person holding a certificate must report for practice once every month. An instructor is in charge of the Station and in daily attendance. The illustration facing page 29 shows this station.

Canadian Collieries (Dunsmuir), Ltd., Extension Colliery, Extension.— This company have just completed a station of frame construction 25 feet by 53 feet, which contains a smoke room, observation room, work room and dressing room.

The course of training consists of preliminary work to give the candidates an introduction to the apparatus, and the method of wearing it, travelling through the various openings in the smoke room, without smoke. This is followed with such practical work as fixing brattice, both cloth and board, cleaning up caves, building stoppings, brick and board, and a stretcher drill in which dummy is rescued from place of danger and carried to place of safety. Mr. J. H. Cunningham, who has taken a course of training at the United States Rescue station at Seattle, Wash., will be the instructor.

The equipment at this Station consists of—

4 sets, two-hour, 1910 model, helmet-type Draeger apparatus
1 oxygen pump
4 oxygen tanks
4 electric safety lamps (Draeger type)

TRAINING FOR COURSE IN MINE-RESCUE WORK

CANDIDATE:.....

Physician's Examination

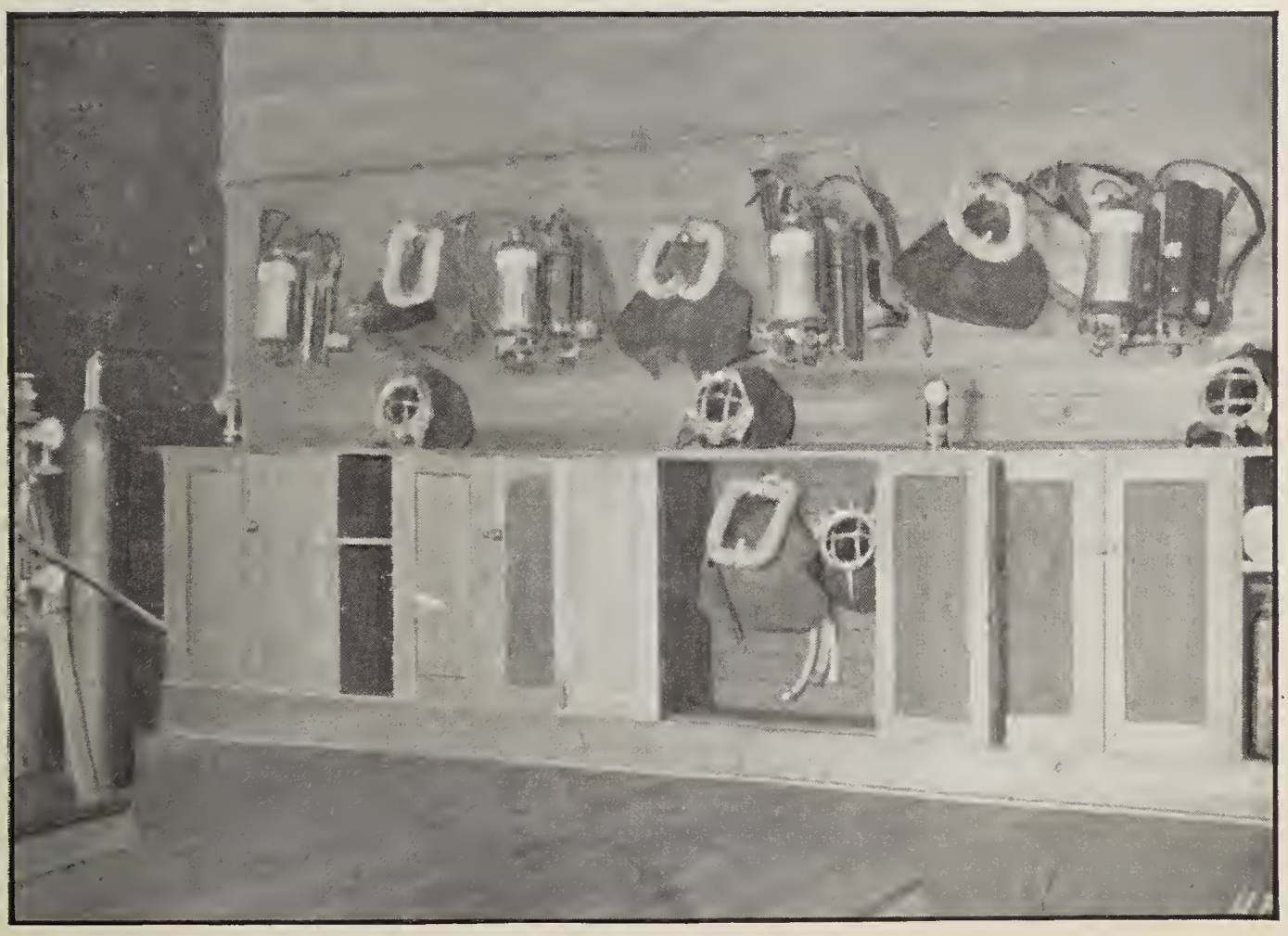
Date.....19...; hour.....M.
Name.....Age.....Residence.....
Occupation.....How long so employed.....
Time of last meal.....Previous illness of recent date, having regard to rheumatism, fits, asthma, giddiness.....
.....
Habits as regards smoking and drinking.....
General appearance with attention to breathing passages, tonsils, nostrils, also ocular conjuntiva, and any infectious condition.....
.....

By Courtesy of Western Fuel Co.

DRAEGER APPARATUS, WESTERN FUEL CO., NANAIMO, B.C.

By Courtesy of J. H. Cunningham

RESCUE STATION, CANADIAN COLLIERIES (DUNSMUIR), LTD., EXTENSION, B.C.



By Courtesy of J. H. Cunningham

APPARATUS ROOM, CANADIAN COLLIERIES (DUNSMUIR), LTD., EXTENSION, B.C.

Urine.....General shape and expansion of the chest.....
Frequency of breathing.....Pulse: frequency.....; and character.....Condition of lungs.....
Condition of arteries and veins.....
Heart action.....
Nervous or composed temperament.....
The candidate is.....in condition to undergo mine-rescue training.

Signed.....
Physician

Condition after Trial

After having executed the first one-hour training in unbreathable air:
General appearance.....
Color.....
Headache, giddiness, vertigo, and unsteadiness of gait.....
.....
Frequency of breathing.....Time required to become normal .....Pulse frequency.....Character, and time required to become normal.....
.....

Signed.....
Foreman

MINE-RESCUE TRAINING RECORD

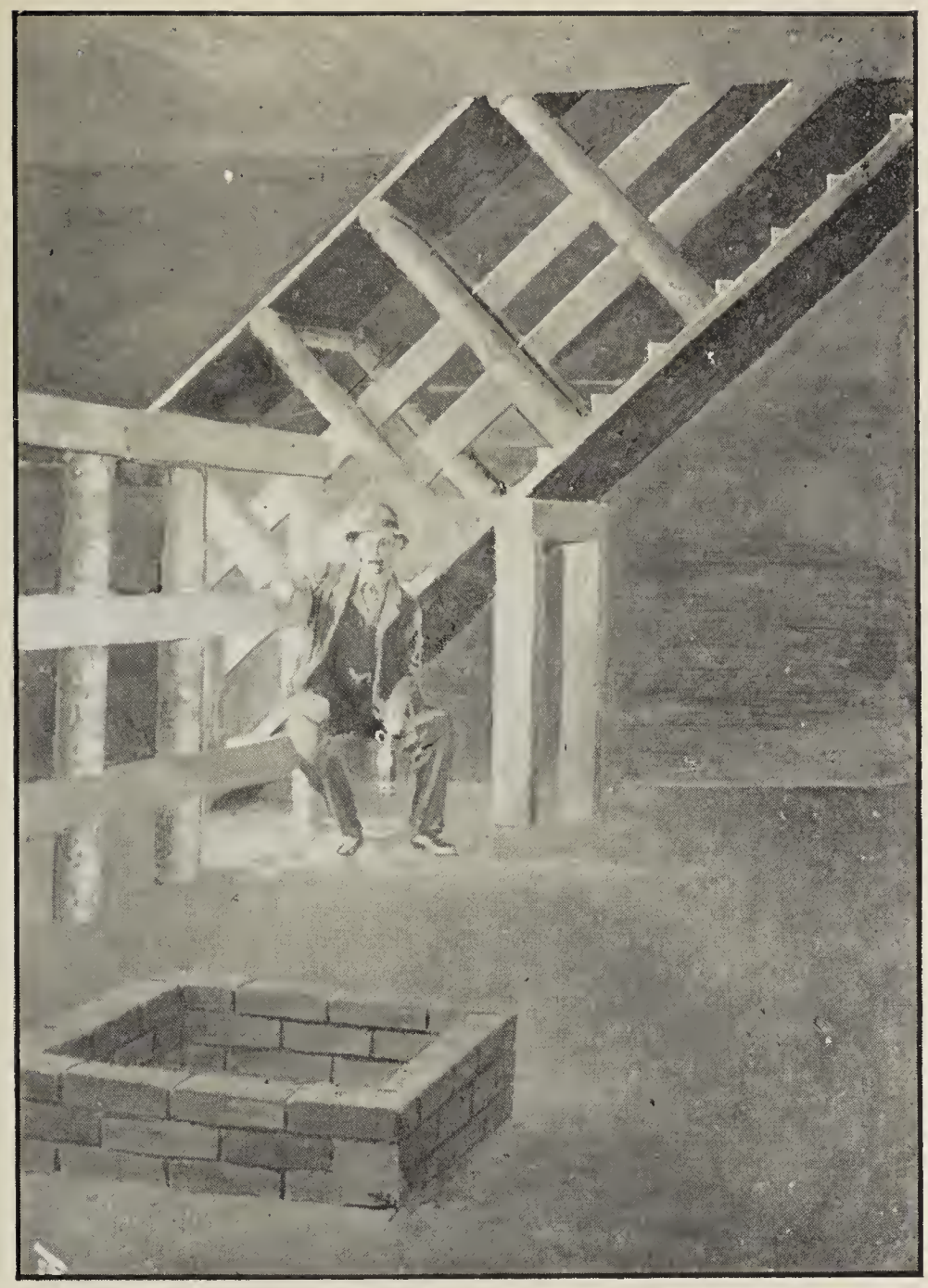
CANADIAN COLLIERIES, LTD., EXTENSION, B.C.

Miner's Name.....No.....Address.....
Mine No.....Occupation.....Chest: Normal.....
Expanded.....Contracted.....Expansion.....Age.....Weight.....
Height.....Where born.....
How long in Canada.....Can he read and speak English .....Married.....How long engaged in mining.....
Coal or metal mines.....
Pulse and respiration while standing: P.....R.....; after hopping 20 ft.: P.....R.....Date on which apparatus was explained.....
.....Time occupied.....Date on which Miner charged and set up apparatus.....
Time occupied.....Type of apparatus used in training.....No.....

Month of training										
Dates of training										
Schedule of training used										
Pump gauge of cylinder:										
Before using										
After "										
Apparatus gauge of cylinder:										
Before using										
After "										
Difference in pump gauge (lbs.)										
" appar. " (min's)										
Actual time apparatus was in use										
Training in SO_2, Smoke or Fresh Air										
Temp. of air										
Distance walked (miles or fract.)										
" crawled (feet)										
Trips over overcast and up incline Route I										
Trips over cave and up incline Route II										
Trips over overcast and back over cave Route III										
Height ascended										
50 pounds bricks carried (feet)										
50 " " lifted (")										
Sawed ends off how many timbers										
Size of timber used										
Number of timbers set up										
Stoppings built — board (W), brick (B), (sq. feet)										
Time for building stopping										
" bratticing incline—cloth (C), board (B)										
Carried "dummy," 150 lbs. (feet)										
Lifted " " (")										
Time for connecting water-pipes T. L. & U										
Pulse just before taking off apparatus										
Dizzy (1), Tired (2), Exhausted (3), Headache (4)										
Percentage										

Total time wearing apparatus.....hours.....min's.
Has the miner full confidence in the apparatus.....
Would he make a good rescue man.....
Rating.....
Is he entitled to a certificate.....
Date.....19... .....

Foreman



By Courtesy of J. H. Cunningham

INTERIOR OF SMOKE CHAMBER, CANADIAN COLLIERIES (DUNSMUIR), LTD., EXTENSION, B.C.

By Courtesy of J. H. Cunningham

RESCUE CORPS, CANADIAN COLLIERIES (DUNSMUIR), LTD., EXTENSION, B.C.

By Courtesy of Vancouver-Nanaimo Coal Co., Ltd.

RESCUE CORPS, VANCOUVER-NANAIMO COAL MINING CO., LTD.

Schedule A—For One-hour Period

1. Walk 12 laps over overcast, up incline, etc. (Route I).
2. Walk 4 laps over cave, through regulator, up incline, etc. (Route II).
3. Saw 4pieces off end of prop (2 men)
4. Carry 10 bricks in sack twice over Route I.
5. Carry "dummy" (150 lbs.) on stretcher over overcast to bottom of incline (2 men).
   Other two men return "dummy" to starting point.
6. Walk round Route I till hour is completed.

Note: This schedule is to be performed on the first day in fresh air with the apparatus; and on succeeding days in a noxious atmosphere.

Schedule B—For One-and-half Hour Period

1. Saw to length and erect one sett (two posts and one stringer) in main road (2 men).
2. Carry air split with brattice-cloth from regulator to top of incline (2 men).
3. Travel one lap in one split around smoke-room and return through other split. Repeat 5 times (Route III).
4. Remove sett of timber and return to place where found.
5. Remove brattice; roll up and return to place where found.
6. Carry 150 bricks in sacks (2 men) to bottom of overcast and empty there; one man carry bricks up overcast; and one man build stopping in overcast.
7. After stopping is inspected, men change places and return bricks.

Note:
1 and 2 are carried on at same time.
2 and 5 " " " " "
6 and 7 will be done by different pairs of men on alternate days.

Schedule C—For Two-hour Period

1. Walk 6 laps around Route I.
2. Build board stopping in main level (2 men).
3. Brattice the incline, with boards (2 men).
4. Enter a water-pipe through side of caved road opposite smoke-pit and carry a line of pipe from this point to the top of incline and a line also to the end of the main level (2 men).
5. Other two men inspect and take down stopping
6. " " " " " " " brattice } and return material to
7. " " " " " disconnect water pipes } place where found.
8. Carry "dummy" through main level, over cave and leave at bottom of incline (2 men).
9. Other two men take "dummy" up incline, down ladder and return to starting point.
10. Stretcher drill.

This company is erecting at their Cumberland colliery a station similar to the one just described. Pending its completion, considerable progress has been made in training men at a temporary station, the equipment of which consists of—

4 sets, two-hour, 1910 model, helmet-type, Draeger apparatus
1 oxygen pump
4 oxygen tanks
4 electric safety lamps (Draeger type)

Half-tone illustrations of the Extension station and interior views face pages 31, 32 and 36.

Vancouver-Nanaimo Coal Company, Nanaimo.—This company has no station but do their work inside the mine. Their equipment consists of—

1 set two-hour, 1911 model, helmet-type, Draeger apparatus
1 set half-hour, mouth-type (Draeger)
1 pulmotor

Training consists of practical work in the mine, such as erecting props, pushing mine cars, loading and unloading cars, etc.

An illustration of the equipment faces page 33.

Pacific Coast Coal Mines, Ltd., South Wellington.—This company has a very creditable station, and has done considerable work in training employees. The course consists of ten sessions in the smoke room, where practice is had in hanging brattice cloth, setting props and carrying dummy over the overcast and through tunnel. The schedule is similar to that of the Western Fuel Company. Practice is also had in the mine.

The equipment consists of—

2 sets two-hour, 1910 model, helmet-type Draeger apparatus
2 sets half-hour, mouth-type Draeger apparatus.
1 pulmotor
4 oxygen tanks
1 oxygen pump
2 electric safety lamps (Draeger).

Nicola Valley Coal and Coke Co., Ltd., Middlesboro.—This company has a small but very creditable station, containing—

2 sets two-hour, 1910 model, helmet-type, Draeger apparatus
4 oxygen tanks
2 electric safety lamps (Draeger type)

The course of training is modelled after that of the Western Fuel Company.

An illustration showing this station will be found facing page 34.

By Courtesy of Pacific Coast Coal Mines, Ltd.

RESCUE STATION AND CORPS, PACIFIC COAST COAL MINES, LTD., SOUTH WELLINGTON, B.C.

By Courtesy of Nicola Valley Coal Co.

RESCUE STATION AND CORPS, NICOLA VALLEY COAL CO., MIDDLESBORO, B.C.

Inland Coal and Coke Co., Ltd., Merritt.—This company has no station nor equipment, but has on order—

2 sets half-hour, mouth-type, Draeger apparatus.

Diamond Vale Collieries, Ltd., Merritt.—This company has no station nor equipment, but are placing an order for—

2 sets two-hour, 1911 model, mouth-type, Draeger apparatus
2 sets half-hour, mouth-type, Draeger apparatus.
4 oxygen tanks
1 oxygen pump
1 pulmotor
4 electric safety lamps (Draeger type)

Corbin Coal and Coke Co., Ltd., Corbin.—This company has no station, their training being done in the mine. It consists chiefly of chute climbing in a vertical seam.

The equipment consists of—

2 sets two-hour, 1910 model, helmet-type, Draeger apparatus
1 set half-hour, mouth-type, Draeger apparatus
1 oxygen pump
6 oxygen tanks
1 pulmotor

Hosmer Mines, Ltd., Hosmer.—This company has no station, their training being done in the mine. Like that of the Corbin Coal Co., it consists of chute climbing. Their equipment consists of—

2 sets two-hour, 1910 model, helmet-type, Draeger apparatus
1 oxygen pump
6 oxygen tanks
1 pulmotor
2 electric safety lamps
1 Draeger inhaler

Crows Nest Pass Coal Co., Ltd., Michel.—This company has no station. Their equipment consists of—

2 sets two-hour, 1911 model, helmet-type, Draeger apparatus
2 sets two-hour, 1911 model, mouth-type, Draeger apparatus
5 sets two-hour, mouth-type, Draeger apparatus
1 pulmotor
6 oxygen tanks
1 oxygen pump
4 electric safety lamps

Crows Nest Coal Co., Ltd., Coal Creek.—This company has no station but has recently commenced training in a disused tunnel. Their equipment consists of—

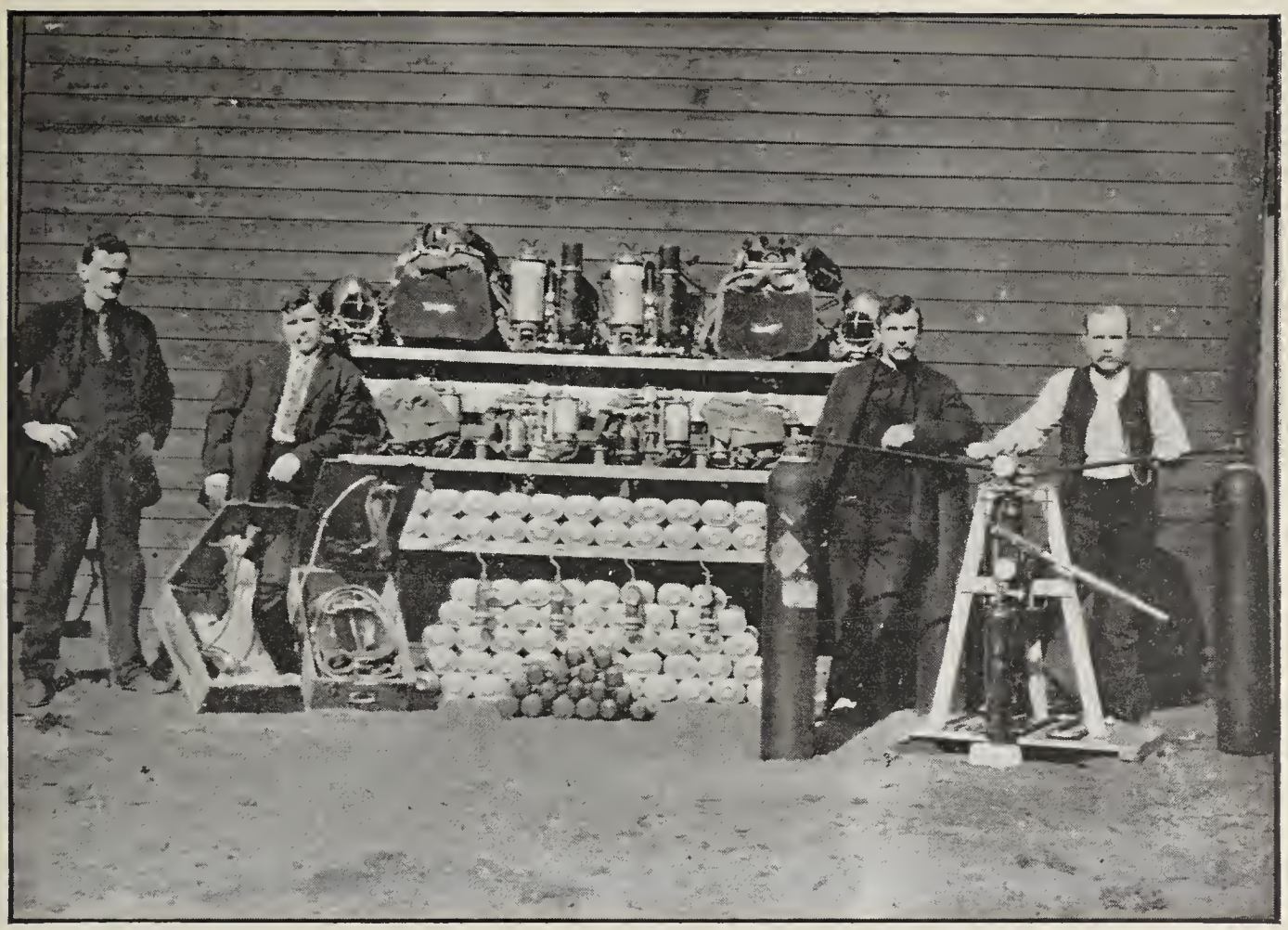
2 sets two-hour, 1911 model, helmet-type, Draeger apparatus
2 sets two-hour, 1911 model, mouth-type, Draeger apparatus
1 set two-hour, Fleuss (Proto) mouth-type apparatus
5 sets half-hour, mouth-type, Draeger apparatus
1 pulmotor
6 oxygen tanks
1 oxygen pump
4 electric safety lamps (Draeger)

There are therefore in British Columbia, at the present time:

44 sets two-hour, Draeger apparatus
22 sets half-hour, Draeger apparatus
5 sets two-hour, Fleuss (Proto) apparatus
3 sets one-hour, Fleuss (Salvator) apparatus
11 pulmotors (Draeger)

There are on order at the present time:

4 sets two-hour, Draeger apparatus
4 sets half-hour, Draeger apparatus
1 pulmotor (Draeger)



By Courtesy of Crows Nest Pass Coal Co.

RESCUE EQUIPMENT, CROWS NEST PASS COAL CO., MICHEL, B.C.

By Courtesy of J. H. Cunningham

OBSERVATION CORRIDOR, CANADIAN COLLIERIES (DUNSMUIR), LTD., EXTENSION, B.C.

By Courtesy of Crows Nest Pass Coal Co.

RESCUE CORPS, COAL CREEK MINES, CROWS NEST PASS COAL CO.

Appendices

APPENDIX I

RESCUE STATIONS AND RESCUE WORK*

Rescue Stations

It is expected that, in the near future, central rescue stations will be established to supply groups of collieries in every mining district. Men from different collieries will thus become acquainted with each other, and in case of a serious accident it is possible that 50 to 100 or more trained volunteers will be quickly in attendance at the scene of the disaster ready to take part in the relief operations. A description of the construction, maintenance, and utilization of central stations and of the rescue corps attached to them would exceed the limits of this paper, especially as it would be necessary to meet the needs of each district, viz., thick and thin seams, flat and steep mines, wet and dry roadways, high temperature, etc. Judging by the discussions which have already taken place at meetings of some of the institutes forming the Institution of Mining Engineers, it is expected that further attention will be devoted to this matter, and codes of rules will be drawn up to suit the various local conditions of each mining centre. Suggestions will also be made for the consideration of collieries respecting the best arrangement for central stations to serve groups of collieries. This "grouping" will depend on the geographical position of collieries in each area. It may be pointed out here that experience has repeatedly shewn that the effects of a serious disaster may be minimized, both as regards life and property, if *immediate assistance* can be given. Each colliery must, and naturally will, consider primarily its own safety; consequently, it will be necessary to keep a certain number of portable breathing apparatus, together with stores of oxygen and chemicals, on the colliery premises. This provision will prevent the loss of valuable time by obviating the necessity of waiting the arrival of apparatus, etc., from the central station, which may be some miles distant.

(*a*) To obtain the full advantage of getting *immediate assistance*, it is suggested that the larger collieries should erect a small gallery to train the men; smaller collieries could utilize an existing building to

* Reprinted, by permission of the author, from "Suggested Rules for Recovering Coal Mines after Explosions and Fires," by W. E. Garforth.

answer the same purpose at a trifling cost. With such an arrangement, and a supply of oxygen, chemicals, etc., each colliery would have a sufficient number of men within call to form the first and second rescue teams to carry on the work until the arrival of the main body of trained men forming the district rescue corps (who will probably arrive from different directions) and of the superintendent from the central station with further supplies of oxygen, chemicals, etc.

(*b*) It is also expected that the proposed rules will make provision for the duplicating of oxygen cylinders, purifiers, etc., periodical inspection and testing of all apparatus, stores, etc., and the registering of the work done by all members so that complete efficiency of both staff and appliances can be maintained.

(*c*) The central station practices should be additional to those undertaken at the colliery; men will meet at the central station and be enabled to form an opinion of each other's capabilities for work, and an advantageous but friendly spirit of rivalry will be maintained, as experience has shown to be the case in ambulance work. The superintendent at the central station will also be able to form a better opinion of each man's capabilities with the view of recommending individual members as leaders of exploration parties, or suitable for specially difficult work, etc.

(*d*) The central station should also be the head-quarters for the keeping of registers of attendance, medical officer's reports, complaints of any descrpition, etc.

(*e*) It should be stipulated that every member of the district rescue corps should agree that he is bound to hold himself in readiness to form one of a rescue party whenever called upon. In the event of wishing to cease being a member, he should give at least one month's notice in writing, so that the chief of each colliery corps may replace him and thereby know on whom to rely.

(*f*) Minor details of the organization and control of sub-stations such as the posting of names and addresses of efficient rescue men, special lamp checks—enabling the officials to see at a glance which men are available in case of need—should be left for decision to the management of each colliery.

Training of Rescue Teams

(*a*) The writer submits, as an example of the training and composition of rescue parties, a scheme which is in operation at a colliery employing nearly 2,000 men with several shafts working three separate

seams of coal, having a total output of 630,000 tons per annum. The teams comprise twenty-four men, six from each pit and six from the surface; the surface unit consists of the manager, the enginewright, three shaftmen, and one electrician; the units from each mine consist of the under-manager, one deputy (day shift), one deputy (afternoon shift), one deputy (night shift), and two under-officials or workmen; each of these teams is under the direction of the resident mining engineer. Each under-manager has a thorough knowledge of the roadways and methods of ventilation of his own mine, and a general knowledge, gained by periodical visits, of the other seams.

(*b*) The selected men have been examined and passed by a medical man. They are to be sound in limb, with perfect hearing, of non-excitable disposition, duly certified as qualified ambulance men and thoroughly acquainted with the underground workings of their respective pits.

(*c*) All the men have been instructed in the construction and handling of the portable breathing apparatus and are able to take it in pieces and put it together again.

(*d*) Experience in the training gallery has shown that one practice per week for three months is sufficient training to enable a man to pass the efficiency test and become practically qualified. Each team consists of at least five men who practice under a qualified leader; in addition to regular practices in the gallery, exploration of disused underground workings or abandoned roads in the mine is valuable training, either walking upright or creeping on hands and knees; all such practices are strictly carried out as if actual exploration after a disaster were being undertaken.

Stores to be Kept at Rescue Stations

The following stock of stores and apparatus should be always on hand at the colliery station:—An adequate number of cylinders, each containing 100 cubic feet of compressed oxygen at a pressure of 120 atmospheres; a special pump for charging the cylinders of the apparatus from the store cylinders without the use of water; the requisite quantity of caustic potash and soda for charging the apparatus; an additional quantity of sealed tins for charging a number of sets of light self-rescue apparatus (if the workmen at any of the collieries in the group have provided themselves with them); an apparatus for supplying oxygen to unconscious men; portable telephone sets and reels of cable for use with and without the apparatus; special stretchers made like sledges for bringing out the injured over fallen roadways; a portable chemical

apparatus for analyzing samples of the mine air similar to those used for analyzing flue gases, and capable of detecting the percentage of oxygen, carbon monoxide and carbon dioxide.* A number of portable electric lamps corresponding to the number of rescue apparatus should be kept ready for use, and smoke helmets similar to those used by firemen might also be stocked for dealing with small fires in the pit or stables, etc.

Requirements of the Apparatus

The rescue apparatus, to be of real practical value, should not be too heavy or cumbersome, and should have its weight distributed over the various parts of the body; an automatic arrangement for the supply of oxygen is essential, as it is often absolutely vital that an explorer should have the free use of both hands; two oxygen cylinders with separate valves are necessary, one for use in advancing and the other for retreating; the gauge recording the pressure of oxygen in the cylinders should be so placed that the wearer can read it either direct or by means of a mirror placed within the protecting cover of the gauge, so that in case he should find himself alone he would immediately be able to determine what amount of oxygen he may have left to enable him to reach a place of safety. The apparatus should allow the head full freedom, and the wearer should be able to breathe in a natural way, not with the nose clipped or the mouth gagged.

The mouthpiece should be so constructed that it may be easily slipped on and off, so that whenever fresh air is encountered, advantage may be taken of it and a corresponding quantity of oxygen saved. The eyes should be protected by goggles for use in smoke, but these should be so arranged that they can be easily removed independently of the helmet as they are often unnecessary in afterdamp. Each apparatus should be capable of supplying the wearer with air as required for a period of at least two hours whilst engaged in laborious work, or for four or five hours if the physical work is easy, as when taking readings of a thermometer in a heated and noxious atmosphere; the cylinders containing the oxygen should be sufficiently strong to withstand a working pressure of 120 atmospheres (1,800 lbs. per square inch) if the generator type of apparatus be used. The chemicals used for the absorption of the carbonic acid gas should be of the very best quality, and not deteriorated by previous exposure to air, and a large surface should be exposed in the purifier for active chemical combination.

* This apparatus will also be found useful for analyzing samples of the air in the breathing apparatus during practice.

Special Warning.

In publishing these suggested rules the writer wishes to state once again the opinion he has repeatedly expressed for several years past respecting every form of portable breathing apparatus which has been introduced:—*That unless the wearer of the apparatus has systematically and regularly practised for three months in a gallery on the surface made like the damaged roadway of a mine, with confined spaces, etc., and been surrounded with an irrespirable, hot, and occasionally humid atmosphere, for at least two consecutive hours, then such an apparatus, instead of being a help to the wearer, may prove to be a* DEATH TRAP.

On the other hand, the writer believes that with proper training a brave and cautious man, accustomed to underground work, will be able to render valuable service in saving life, affording relief to sufferers, safeguarding explorers, and protecting property. In support of this opinion the reader is asked to consider the difference between a trained and untrained sailor or soldier.

Suggested Rules for Guidance *AFTER* an Accident

Use of Portable Breathing Appliances or Rescue Apparatus—At collieries where only the downcast shaft is used for winding coal, an explosion is generally most severely felt in the neighbourhood of this shaft and on the haulage roads in its vicinity, probably due to the propagation of the explosive blast by coal dust; on the return airways, however, and in the neighbourhood of the upcast pit, the stone dust on the floor, sides, roof, etc., usually caused by the passage of men and horses, tends to reduce the explosive blast to inertness. As a result of this, or in case of a fire at the downcast pit, or owing to the winding appliances being damaged, it frequently occurs that a descent can best be made by means of the upcast shaft, and as in such a case the air would be irrespirable, portable breathing appliances would be necessary. The limits of usefulness of the apparatus will depend on the amount of training which the rescuers have undergone in a suitable experimental gallery, the physical condition of the men, the perfectness of the apparatus, the state, height and inclination of the roadways, the heat of the surrounding atmosphere, the obstructions to be removed, and the allowance to be made for contingencies, such as falls of roof between the explorers and safety. The following rules, as well as many of the foregoing, must then be observed.

Immediately on being advised of a disaster, the official in charge of the rescue station should despatch to the pit affected the specified number of complete sets of apparatus.

All apparatus should be tested before being used, for air tightness. It is suggested that the weigh cabin on the pit bank should be made air-tight, so that by filling it with sulphur or other noxious fumes each explorer could enter it and so test his apparatus before descending the shaft. Apparatus with injectors should be tested by water-gauge, or the quantity of air supplied measured with a suitable appliance such as a graduated bag, which can be unrolled as it is filled. Intermittent or lung-governed valves should be tested by suction before coupling up. All joints subject to high pressure should be made and tested before being sent out of store. The name and address of each man, the number of his check, the pressure of oxygen and the condition of his apparatus should, at the commencement of each shift of exploration work, be recorded in a special book.

One member of the rescue party should have a telephone so attached that it can be used while the apparatus is being worn. Pneumatic horns should be worn stitched in the clothing of each member of the party to be sounded by movement of the arm; these horns would serve as alarms in case anyone was cut off from the main body of explorers as by a fall of roof, or injured himself or required to draw attention to some danger.

Rules to be Observed by Exploration Parties Equipped with Apparatus—The first exploration party wearing the apparatus should consist of eight men; subsequent parties may be reduced to not less than five. While the leading man is taking instructions from the chief in charge of the exploration work, the second in command should be inspecting the apparatus of his party, testing all joints with a lighted taper, and seeing that each cylinder is charged to the maximum pressure (120 atmospheres) and in working order. No man should be allowed to descend the pit if his apparatus shows the slightest defect, if any defect is apprehended, or if his apparatus is in any way uncomfortable. None but efficients —that is, men thoroughly trained in wearing the apparatus, and holding a certificate of competency—should be allowed to form members of such rescue parties.

The leader or captain of a rescue party must not interfere in the general conduct of the relief operations unless specially appointed. The management must state what is to be attempted. The leader should, however, be consulted as to whether the plan proposed is practicable for the rescue party, and his opinion should be taken as to the best method of carrying it out.

The leader of each party should be relieved as much as possible from extra physical work, his duty being to supervise the work in hand,

and to take care of the men under his charge. The other men should share all hard work equally, in order that the oxygen and chemicals of no one apparatus may be exhausted much earlier than the rest. As soon as any member of the party has used about half his supply of oxygen, the whole party must consult, or indicate by special signs, as to the advisability of returning to a place of safety. Should any man's apparatus not be working satisfactorily he must return immediately to a place of safety accompanied by at least one other man. If the party should by this means be reduced to less than four, risk is involved, and the whole party should return.

The same precautions as mentioned in Rule 16 (*c*)* as to leaving two men at the pit bottom to give signals, etc., must be strictly observed when men are using life-saving apparatus.

Each party should carry two or three pocket thermometers for the reasons already stated, also a light sheet iron stretcher provided with sledge runners (these runners have been found useful in passing over falls). Not only will it be found of service for carrying men, but also for transporting restoratives, food, brattice cloth, tools, etc.

During preliminary explorations, the party should not be away from safety for more than about one hour; this time may afterwards be extended, especially if the party is in telephonic communication with the base of operations.

As soon as possible, stations or bases should be established in the pit, where the ventilation has been restored, from which extended explorations may be made, and at which the apparatus can be re-charged, thus saving the time, oxygen and chemicals which would otherwise be necessary to enable the men to return to the surface. These stations should be in telephonic communication with the pit bank.

Parties wearing apparatus will act chiefly as scouts advancing ahead of the ventilation to prove the existence of and to deal with fires. Their principal and foremost duty will be, however, to relieve survivors cut off from the pit by afterdamp. When certain of the roadways have been made passable for travelling without apparatus, the most convenient arrangement would be to divide each exploration party into men with and without the apparatus; the former would lead and inspire confidence in the latter, as they would be able to rescue them promptly should they be overcome by afterdamp, whilst, if the air is breathable

* Rule 16—Two men must always be left at the pit bottom, whenever exploration parties are at work, to give the necessary signals in case the party return in an exhausted condition, or when an immediate ascent is necessary, etc.

but the roadway obstructed by heavy falls, the latter would help to make it passable and expedite the work of recovery.

Extra electric lamps should be taken by some members of the party for use in case any of the other lamps get damaged.

A relay of men with the apparatus all ready for finally connecting should be in attendance near the pit head, to save time in the event of a sudden call or signal from below ground for further assistance. A further number of men, sufficient to make up two more parties, should also be at hand ready to put on the apparatus immediately the first relay is called upon. Each of these parties would thus in their turn act as chief exploration party.

It must be impressed on the men that whilst wearing the apparatus they must not be carired away with the spirit of emulation or work to their utmost strength, but must keep well within the bounds of their own capabilities and those of the apparatus. They will learn by experience when and how much food to take before going on duty.*

* Had there been sufficient relays of men equipped with portable breathing apparatus at the Hamstead Colliery disaster more satisfactory results would have been obtained, and probably the life which was lost might have been saved. Seven men with the apparatus were trying to do the work of thirty.

APPENDIX II

RESCUE WORK IN MINES†

Equipment of Rescue Men

A rescue party should have not less than five, and better not less than six, members. Only such persons should be allowed to join the party as have already been trained in the use of the apparatus, are equipped with rescue apparatus in good order and have agreed to follow the directions of the leader, who must have full charge. While working in unbreathable gases within a mine, the men should keep close to one another and not separate under any condition.

To be efficient and successful a party must take every precaution for its own safety. If one person in a party faints or receives an injury, he becomes a burden instead of a help, for the entire party must at once conduct him to the surface or to fresh air. One or two stretchers should always be at hand.

A relief station or base of operations should be established at the end of the good air and a relief crew with knapsacks should be stationed there ready to put on their apparatus and start at a moment's notice. A patrol of all brattice and doors leading up to the relief station should be maintained to protect the relief crew from harm.

At each large mine there should be at least four crews—two outside and two inside crews—each of six men, including a captain and a lieutenant, and these crews should have practice once a week.

While working in dense smoke the members of a crew should hold a rope which leads to fresh air.

In case the regenerator in a Draeger No. 1 or Westfalia apparatus is punctured by a fall of rock or by striking a nail, the wearer should get to fresh air as soon as possible, accompanied by the other members of the party. If a Draeger No. 2 apparatus is similarly damaged the wearer can throw the cartridge away and breathe from the bag, relieving the pressure every ten or fifteen steps by opening the lower valve on the cartridge support or by pressing on the bags.

In case of total failure of an apparatus to supply breathable air, the wearer of the apparatus can throw away all parts but the oxygen cylinder, and breathe from the cylinder through his mouth while endeavouring to reach fresh air with the rest of the crew.

† Extracted from Miners' Circular 4, United States Bureau of Mines.

Apparatus for giving oxygen to one who has been overcome with gases is an essential part of the equipment of a rescue party.

A telephone helmet is a convenience for shaft work, and its presence lends much confidence to a rescue party. Electric lamps, safety lamps, gas-analysis apparatus, thermometers, a pocket compass, and a map of the mine are necessary parts of the equipment.

At each training station a record should be kept showing the work done by the men and the difficulties encountered. A record of each apparatus should be kept also. If an apparatus fails to give proper service it should be subjected to the regular tests unless some injury is seen upon inspection.

APPENDIX III

RECOMMENDATIONS OF NATIONAL MINE-RESCUE CONFERENCE

The following is an outline of the conditions recommended to be observed in the conduct of mine-rescue work, by the National Mine-rescue Conference held at Pittsburg, September 25, 1912. The conference further resolved that men untrained in rescue work should not be permitted to use breathing apparatus except when such a course is the only possible one for saving life. In selecting untrained men, discipline is of equal importance to training.

Outside Organization

1. All openings should be carefully guarded.

2. There should be a man in charge of outside arrangements to see that ventilating appliances are put in condition for operation.

3. Precaution should be taken to see that competent men are placed at all openings to the mine, and that they obey the orders given.

4. A competent person should be placed near the entrance to the mine to examine all safety lamps before they are allowed to be taken into the mine.

5. Some specified person should be placed at the entrance to check off all persons and make a record when they go into and come out of the mine.

6. Proper provisions should be made for providing food and shelter for persons engaged in rescue work.

7. A physician should be on hand while rescue parties are in the mine.

8. Safety lines should be established around all openings, and inside of these lines no open lights should be allowed.

9. A man in charge of the rescue squads should have them in readiness to enter the mine when called upon.

Inside Organization

1. A man should have full charge of the inside operations on each shift.

2. There should be an advance squad under a competent leader to explore the workings in advance of the other squads who are advancing the ventilation, making repairs, and carrying stretchers.

The squads are to advance in the following order:

(a) Breathing apparatus or advance squad.
(b) Stretcher squads.
(c) Temporary ventilation squad.
(d) Material squad.
(e) More permanent ventilation squad.

3. A base of operations should be established at a suitable point, and there should be placed in charge of it a competent person who should re-examine all lights before they pass beyond him to the interior of the mine.

4. A telephone, communicating with the surface, should be placed at this station, and should be carried into the workings as fast as possible.

5. No persons should go in advance of the ventilating current except the advance squad. The duty of this squad is to make an examination of the atmosphere for gas, examine the return air-current frequently for indications of fire; and be on the look-out for any other dangers.

6. A doctor, with the necessary medical and surgical supplies, should be stationed at this inside station.

7. While the parties are advancing into the mine all unexplored openings should be marked off as dangerous.

8. Strict discipline should be maintained at all times.

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